Nos. 2022-1904, 2022-1925

# UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

OPTIS CELLULAR TECHNOLOGY, LLC, OPTIS WIRELESS TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, UNWIRED PLANET, LLC,

*Plaintiffs-Cross-Appellants*,

*v.*

APPLE INC.,

*Defendant-Appellant.*

On Appeal from the United States District Court for the Eastern District of Texas in Case No. 2:19-cv-00066, Judge James Rodney Gilstrap

## CORRECTED NON-CONFIDENTIAL BRIEF FOR DEFENDANT-APPELLANT APPLE INC.


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April 28, 2025

## REPRESENTATIVE PATENT CLAIMS

**Claim 6 of U.S. Patent No. 9,001,774 recites:**

A method, comprising:

receiving a processing parameter for transmission of data on two antenna ports, the processing parameter including at least one of a time delay, a phase rotation and a gain determined based on a received uplink signal;

receiving a first pilot, a second pilot, a first data symbol and a second data symbol transmitted on the two antenna ports; and

demodulating the first data symbol and the second data symbol based on the processing parameter, the first pilot and the second pilot.

Appx354-355.

**Claim 6 of U.S. Patent No. 8,019,332 recites:**

A user equipment (UE) for decoding control information, the UE comprising:

a receiver for receiving a Physical Downlink Control Channel (PDCCH) from a base station at subframe k; and

a decoder for decoding a set of PDCCH candidates within a search space of the PDCCH at the subframe k, wherein each of the set of PDCCH candidates comprises 'L' control channel elements (CCEs),

wherein the 'L' CCEs corresponding to a specific PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation, wherein 'C' is determined as 'floor(N/L)', wherein 'N' represents a total number of CCEs in the subframe k, and

wherein $Y_k$ is defined by:

$Y_k=(A*Y_{k-1})\mathrm{mod}\ D$,

wherein A, and D are predetermined constant values.

Appx291-292.

**Claim 1 of U.S. Patent No. 8,385,284 recites:**

A mobile terminal for use in a mobile communication system, the mobile terminal comprising:

a receiver unit for receiving a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal,

a processing unit for determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and

a transmitter unit for transmitting the protocol data unit on at least one physical radio resource using the transport format and the redundancy version of the protocol data unit indicated in the received control channel signal,

wherein the control channel signal received within said sub-frame comprises a control information field, in which the transport format and the redundancy version of the protocol data unit are jointly encoded,

wherein the processing unit is further configured for the determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field, wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data, and

wherein the first subset of the values contains more values than the second subset of the values.

Appx317-318.

**Claim 8 of U.S. Patent No. 8,102,833 recites:**

A mobile station for transmitting uplink signals comprising control signals and data signals in a wireless communication system, the mobile station comprising:

a processor serially multiplexing first control signals and data signals, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals;

the processor mapping the multiplexed signals to a 2-dimensional resource matrix comprising a plurality of columns and a plurality of rows, wherein the columns and the rows of the 2-dimensional resource matrix correspond to single carrier frequency divisional multiple access (SC-FDMA) and subcarriers for each SC-FDMA symbol, respectively, wherein a number of columns of the 2-dimensional resource matrix corresponds to a number of SC-FDMA symbols within one subframe except specific SC_FDMA symbols used for a reference signal, and wherein the multiplexed signals are mapped from the first column of the first row to the last column of the first row, the first column of the second row to the last column of the second row, and so on, until all the multiplexed signals are mapped to the 2-dimensional resource matrix; and

the processor mapping ACK/NACK control signals to specific columns of the 2-dimensional resource matrix, wherein the specific columns correspond to SC-FDMA symbols right adjacent to the specific SC-FDMA symbols, wherein the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix from the last row of the specific columns.

Appx371.

**Claim 1 of U.S. Patent Nos. 8,411,557 recites:**

A mobile station apparatus comprising:

a receiving unit configured to receive control information;

a selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts; and

a transmitting unit configured to transmit the selected sequence,

wherein a position at which the predetermined number of sequences are partitioned is determined based on the control information, and a number of sequences contained in each of the plurality of groups varies in accordance with the control information.

Appx338.

## CERTIFICATE OF INTEREST

Counsel for Defendant-Appellant Apple Inc. certifies the following:

**1. Represented Entities**. Fed. Cir. R. 47.4(a)(1). Provide the full names of all entities represented by undersigned counsel in this case.

Apple Inc.

**2. Real Party in Interest**. Fed. Cir. R. 47.4(a)(2). Provide the full names of all real parties in interest for the entities. Do not list the real parties if they are the same as the entities.

None.

**3. Parent Corporations and Stockholders**. Fed. Cir. R. 47.4(a)(3). Provide the full names of all parent corporations for the entities and all publicly held companies that own 10% or more stock in the entities.

None.

**4. Legal Representatives**. List all law firms, partners, and associates that (a) appeared for the entities in the originating court or agency or (b) are expected to appear in this court for the entities. Do not include those who have already entered an appearance in this court. Fed. Cir. R. 47.4(a)(4).

WILMER CUTLER PICKERING HALE AND DORR LLP: Heath A. Brooks, Ravinder Singh Deol, Ben Ernst, Josefina Garcia, Joseph F. Haag, Jennifer J. John, Alexander J. Nemtzow, Kevin J. O'Brien, Amy R. Pearlman, James L. Quarles, III, Michaela P. Sewall, Mary V. Sooter, Michael J. Summersgill, Daniel C. Wewers, Kathryn Zalewski

WALKER STEVENS CANNOM YANG LLP: Hannah L. Cannom, Bethany M. Stevens

GILLAM & SMITH LLP: Melissa R. Smith, James T. Underwood

**5. Related Cases**. Provide the case titles and numbers of any case known to be pending in this court or any other court or agency that will directly affect or be directly affected by this court's decision in the pending appeal. Do not include the originating case number(s) for this case. Fed. Cir. R. 47.4(a)(5). *See also* Fed. Cir. R. 47.5(b).

None.

**6. Organizational Victims and Bankruptcy Cases**. Provide any information required under Fed. R. App. P. 26.1(b) (organizational victims in criminal cases) and 26.1(c) (bankruptcy case debtors and trustees). Fed. Cir. R. 47.4(a)(6).

None.

Dated: April 28, 2025

/s/ Mark C. Fleming

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**CONFIDENTIAL MATERIAL OMITTED**

The material omitted from the first, second, fourth, and fifth redactions on page 60 contain confidential information regarding the scope of a settlement agreement between Apple and Qualcomm; the third redaction from page 60, the redactions on page 61, and the second and third redactions on page 63 contain confidential information regarding the value of a settlement agreement between Apple and Qualcomm; the first redaction on page 62 and the first, fourth, and fifth redactions on page 63 contain the confidential parties to a confidential licensing agreement; the second and third redactions on page 62 and the sixth and seventh redactions on page 63 contain confidential information regarding the scope of that confidential licensing agreement; the material omitted from Addendum page Appx63 contains confidential information regarding the settlement agreement between Apple and Qualcomm; and the material omitted from Addendum pages Appx231-232, Appx235-240, Appx243, Appx248-252, Appx254-255, Appx258, and Appx262-264 contains confidential information regarding license agreements and licensing negotiations, and confidential sealed testimony regarding the same.

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## STATEMENT OF RELATED CASES

Three of the patents-in-suit—U.S. Patent Nos. 8,411,557 ("'557 patent"), 9,001,774 ("'774 patent"), and 8,102,833 ("'833 patent")—were the subject of an *inter partes* review appealed to this Court in *Apple Inc. v. Optis Cellular Technology, LLC*, Nos. 2021-1043, -1044, -1046, 2020 WL 7753630 (Fed. Cir. Dec. 21, 2020) (Lourie, J., joined by Prost, C.J. and Chen, J.).

## INTRODUCTION

Plaintiffs—collectively "Optis"—accused various Apple iPhone, iPad, and Watch models of infringing patents relating to how cellular devices communicate with base stations (cell towers). After a first jury verdict, the district court vacated the damages award and conducted a damages-only retrial, in which the second jury awarded $300 million in damages. But the judgment suffers from numerous errors, each alone requiring vacatur.

Fundamentally, the verdict forms used in both the initial trial and the retrial invalidate the judgment. The infringement verdict was an answer to a single question covering all five patents. This allowed the jurors to find infringement even if they disagreed on which patent was infringed, thus violating Apple's right to jury unanimity. It was therefore impossible for the retrial jury to know which patents were found infringed; the district court wrongly instructed that ***all*** patents were infringed, which the first jury never found and was never asked to find. And

because the damages-only verdict was undifferentiated, it cannot be remitted to correspond to a new trial's patent-specific infringement findings (if any). Accordingly, the infringement and damages verdicts are irretrievably mismatched and should be vacated.

The infringement verdict should be reversed or vacated for additional reasons: there is insufficient evidence of infringement as to all five patents; U.S. Patent No. 8,019,332 ("'332 patent") is directed to a patent-ineligible abstract mathematical formula; the court misconstrued the '833 patent; and the '557 patent includes an indefinite means-plus-function limitation. Because of the general verdict, ***any one*** of these errors requires vacatur of the entire infringement verdict, which in turn (as noted) requires vacatur of the damages verdict because remittitur is impossible.

The damages verdict should also be vacated for further reasons. The district court erroneously admitted: evidence regarding non-comparable agreements; Apple's general profitability in the cellular industry—not just profits from the asserted patents; and confidential statements by the parties during their settlement negotiations. The case should at a minimum be retried to a jury whose deliberations are not affected by that inadmissible and unfairly prejudicial testimony.

## JURISDICTIONAL STATEMENT

The district court had jurisdiction under 28 U.S.C. §§1331, 1338, entered judgment on September 8, 2021, Appx220, and denied post-trial motions on May 17, 2022, Appx223-264. Apple timely appealed. Appx8905-8908. This Court has jurisdiction under 28 U.S.C. §1295(a)(1).

## STATEMENT OF ISSUES

1. Whether the first trial's verdict form violated Apple's right to jury unanimity.

2. Whether the judgment should be reversed or vacated because:

   a. Optis failed to prove infringement of the '774 patent;

   b. the asserted claims of the '332 patent are patent-ineligible, and/or Optis failed to prove infringement of the '332 patent;

   c. Optis failed to prove infringement of U.S. Patent No. 8,385,284 ("'284 patent");

   d. the district court erroneously construed the asserted '833 patent claim, and/or Optis failed to prove infringement of the '833 patent; and/or

   e. the '557 patent contains an indefinite means-plus-function limitation; Optis failed to prove infringement of the '557 patent;

and/or Optis failed to prove infringing use of the claimed method in the United States.

3. Whether the damages award should be vacated because:

   a. it was not based on an actual infringement verdict;

   b. the district court erroneously admitted evidence regarding non-comparable Apple-Qualcomm agreements;

   c. the court erroneously admitted evidence of Apple's general profitability in the cellular industry; and/or

   d. the court erroneously admitted evidence of the parties' confidential settlement negotiations.

## STATEMENT OF THE CASE

### A. The First Trial

Optis accused various iPhone, iPad, and Watch models of infringing patents allegedly essential to the 4G (LTE) cellular standard (standard-essential patents, or "SEPs"). Accordingly, Optis was required to offer licenses to those patents under fair, reasonable, and non-discriminatory ("FRAND") terms. Appx137. Ultimately nine claims from five patents were asserted. Appx153.

Following pretrial rulings, *see* Appx1-58; Appx60; Appx63-64; Appx66-78, both parties proposed a verdict form asking the jury to decide infringement of each patent individually. *See* Appx8264. Over Apple's objection, Appx96; Appx2606,

the court posed a single infringement question covering all patents together: "Did Optis prove by a preponderance of the evidence that Apple infringed **ANY** of the asserted claims?" Appx101 (emphasis original).[1] The jury answered "Yes" and awarded $506,200,000 in running royalty damages. Appx101; Appx104. The court entered judgment stating, *inter alia*, "Apple has infringed ***one or more*** of the Asserted Claims." Appx134.

Apple moved for judgment as a matter of law and a new trial on multiple grounds. The court granted a new trial on damages only, because the court had erroneously excluded evidence of Optis's FRAND obligation. Appx136-146; Appx152-185.

**B. The Damages Retrial**

The court admitted, over Apple's objections, evidence regarding: separate agreements between Apple and Qualcomm, Appx195; Appx202-203; Appx3174-3175; Apple's general profitability in the cellular industry, Appx195-196; Appx3510; and confidential statements from the parties' settlement negotiations, Appx150; Appx194-195.

The court instructed the retrial jury, over Apple's objection, to determine a single damages amount for ***all five*** patents, although the original verdict and judgment did not specify which patents were infringed, let alone that all five were.

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[1] Emphases added unless otherwise noted.

Appx203; Appx3183. The jury awarded an undifferentiated lump sum of $300,000,000. Appx217. The court entered judgment, Appx220, and denied Apple's post-judgment motions, Appx223-264.

## SUMMARY OF THE ARGUMENT

I.A. The first verdict form violated Apple's right to jury unanimity by posing a single infringement question covering all five asserted patents, meaning that Optis could prevail even if the jurors did not agree on which individual patents were infringed. A new trial is required in which the jury is required to find whether Apple infringed each patent individually.

B. Optis failed to prove that Apple's products "receiv[e] a processing parameter" as the '774 patent requires. Rather, Apple's products undisputedly ***compute*** processing parameters by combining several inputs, some prestored on the device and some received through multiple transmissions. That is not "receiving" a processing parameter and thus cannot literally infringe. And Optis offered no particularized evidence explaining how ***computing*** a processing parameter is equivalent to ***receiving*** one.

C. The asserted '332 patent claims are ineligible because they are directed to an abstract mathematical formula, and their non-formula elements were admittedly known and conventional. Optis also failed to prove infringement because Apple's products undisputedly do not perform the required calculation.

D. Optis failed to prove infringement of the ’284 patent’s requirement that a “first subset of values contains more values than the second subset.” The evidence indisputably shows the first subset in Apple’s products has ***fewer*** values than the second. Optis prevailed only because the district court erroneously permitted it to present a new claim construction to the jury that contradicted the limitation’s text.

E. The district court erroneously construed the asserted ’833 patent claim, which requires mapping begin “***from***” the last row of a matrix and proceed toward the first row, not (as the court held) that the system merely map cells ***in*** the last row. And Optis failed to prove infringement even under the erroneous construction because Apple’s products perform the specified mapping column-by-column, not row-by-row as the claims require.

F. The ’557 patent’s claim 1 is indefinite because it nowhere discloses sufficient structure for the claimed “selecting unit.” Optis also failed to prove infringement of claims 1 and 10 because Apple’s products do not literally “select” or “generate[]” the claimed sequences, and Optis supplied only incoherent and circular testimony for its DOE theory. Finally, Optis adduced no evidence that Apple or its customers performed claim 10’s method in the United States.

G. Any of the foregoing errors alone requires vacatur of the entire judgment. Due to the single-question infringement verdict, the Court cannot

exclude the risk that the jury relied on an erroneous or unsupported theory, and the undifferentiated damages award makes it impossible to remit it to match any revised infringement finding on remand.

II.A. The damages verdict should be vacated because it was impossible for the retrial jury to know which, if any, patents were found infringed by the first jury. The district court erred in instructing the retrial jury that ***all*** patents were infringed, which the first jury never found.

B. The court erroneously admitted evidence regarding Apple-Qualcomm agreements that are concededly noncomparable to the hypothetical FRAND negotiations required here and improperly skewed the damages horizon.

C. The court erroneously admitted evidence regarding Apple's general profitability in the cellular industry that was disconnected from the accused features and contrary to FRAND principles.

D. The court erroneously admitted evidence from the parties' confidential settlement negotiations, contrary to Rule of Evidence 408, the parties' confidentiality agreement, and FRAND principles.

## ARGUMENT

### I. STANDARD OF REVIEW

Patent eligibility is reviewed de novo, *Enfish, LLC v. Microsoft Corp.*, 822 F.3d 1327, 1334 (Fed. Cir. 2016), as is claim construction, including whether a

claim is a means-plus-function claim, *Diebold Nixdorf, Inc. v. ITC*, 899 F.3d 1291, 1297 (Fed. Cir. 2018). Denial of JMOL is reviewed de novo. *Network-1 Techs., Inc. v. Hewlett-Packard Co.*, 981 F.3d 1015, 1026 (Fed. Cir. 2020). Denial of a new-trial motion is reviewed for "an abuse of discretion or a misapprehension of the law." *Sulzer Textil A.G. v. Picanol N.V.*, 358 F.3d 1356, 1363 (Fed. Cir. 2004).

"The Fifth Circuit reviews the trial court's admission or exclusion of expert testimony for an abuse of discretion." *Ericsson, Inc. v. D-Link Sys., Inc.*, 773 F.3d 1201, 1225 (Fed. Cir. 2014).

## II. THE INFRINGEMENT JUDGMENT SHOULD BE REVERSED OR VACATED

### A. By Asking A Single Infringement Question For All Patents, The Verdict Form Violated Apple's Right To Jury Unanimity

Apple had a right to a unanimous verdict regarding infringement. *Andres v. United States*, 333 U.S. 740, 748 (1948) ("Unanimity in jury verdicts is required where the … Seventh Amendment[] appl[ies]."); *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 377 (1996) (Seventh Amendment applies to patent "infringement"); Fed. R. Civ. P. 48(b) ("the verdict must be unanimous"). The verdict form denied Apple that right because it did not ensure that the jury unanimously found infringement of any particular patent. In fact, the form allowed Optis to win even if it lost on each individual patent. Therefore, the infringement judgment should be vacated, and a new trial ordered. *See Prudential Ins. Co. of Am. v. Morrow*, 339 F.2d 411, 412 (5th Cir. 1964).

"[I]n a general verdict the jury announces only the prevailing party ***on a particular claim***." *Zhang v. American Gem Seafoods, Inc.*, 339 F.3d 1020, 1031 (9th Cir. 2003). Where, as here, there are multiple claims, the jury should return a separate general verdict "as to each claim": "the key" to a valid general verdict is "whether the jury announces the ultimate legal result ***of each claim***." *Id.* A single general-verdict question covering multiple causes of action is improper, as it allows the plaintiff to prevail even if the jurors do not agree that it carried its burden on any claim. *See Hager v. Gordon*, 171 F.2d 90, 93 (9th Cir. 1948) (court erred by using general-verdict form that "so interwove the two causes of action as to virtually preclude the jury from separating the two causes of action and presenting a finding as to the merit or lack of merit they may have found in each").

In the patent context, "[e]ach patent asserted raises an independent and distinct cause of action," and therefore "infringement must be separately proved as to each patent." *Kearns v. General Motors Corp.*, 94 F.3d 1553, 1555-1556 (Fed. Cir. 1996). Accordingly, each of the five asserted patents defined a distinct cause of action with a distinct asserted injury—and Optis pled its case that way, Appx4917-4983(¶¶66-126)—not five alternative theories for a single common injury.

Contrary to both parties' proposals and over Apple's objection, Appx8264; Appx96; Appx2606, the verdict form's Question 1 covered all asserted patents:

"Did Optis prove by a preponderance of the evidence that Apple infringed **ANY** of the asserted claims?" Appx101 (emphasis original). The jury simply answered "Yes." Appx101. While the jury was told that "answers to each question must be unanimous," Appx98, that did not protect Apple's right to unanimity on each cause of action; the question's phrasing—"infringed **ANY** of the asserted claims"—allowed an affirmative answer if every juror believed ***some*** patent was infringed, but did not agree on ***which***. For example, the jury could have answered Question 1 in the affirmative if only two jurors believed Apple infringed the '284 patent, only two believed Apple infringed the '332 patent, only two believed Apple infringed the '557 patent, only one believed Apple infringed the '774 patent, and only one believed Apple infringed the '833 patent. Put simply, the verdict form allowed Optis to win even if it lost on each individual patent.

It is undisputed that the verdict form did not require unanimity with respect to any single patent—indeed, Optis itself had proposed a patent-by-patent form. *See* Appx8264. Yet the district court never explained why it overruled Apple's objections to the verdict form—not during the charge conference (Appx96; Appx2606) or in denying post-judgment relief (Appx184-185). Because the form violated Apple's right to a unanimous verdict on each cause of action against it, a new infringement trial is required, and as discussed below (Part III.A), correspondingly a new damages trial is also required.

Moreover, sustaining any one of the errors identified in Part II.B-F will require vacatur of the entire infringement judgment, which, again, will require vacatur of the damages verdict. *See infra* Parts II.G, III.A.

**B. The '774 "Processing Parameter" Patent**

In some multiple-antenna transmission schemes, each antenna sends a different version of the same data to the cellular device (also called "user equipment" or UE). Such a system may use processing parameters to exploit the differences in the transmission channels to increase the likelihood that the data is successfully received. Asserted claim 6 of the '774 patent recites:

> A method, comprising:
>
> ***receiving a processing parameter*** for transmission of data on two antenna ports, ***the processing parameter including at least one of a time delay, a phase rotation and a gain*** determined based on a received uplink signal;
>
> receiving a first pilot, a second pilot, a first data symbol and a second data symbol transmitted on the two antenna ports; and
>
> demodulating the first data symbol and the second data symbol based on the processing parameter, the first pilot and the second pilot.

Appx354-355.

The district court construed the processing-parameter limitation to require receiving "at least one time delay, at least one phase rotation, or at least one gain." Appx49. Optis failed to prove literal or DOE infringement.

### 1. Literal infringement

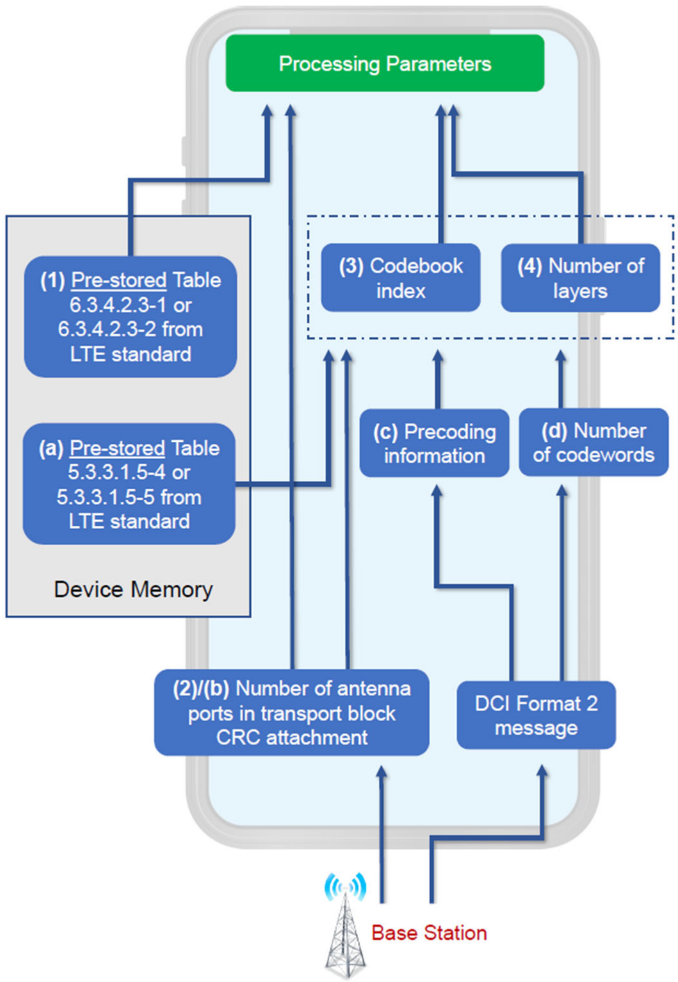
No transmission "received" by Apple's devices includes any of the recited processing parameters (time delay, phase rotation, or gain). Rather, as Apple's expert Dr. Wells explained, an Apple device "***computes*** a processing parameter itself"; it does not ***receive*** it. Appx2285.

The mechanics of Apple's products are undisputed. The phase rotation and gain are computed by Apple's devices. *See* Appx26466-26467; Appx35059-35060. To do this, a device uses four inputs: (1) a table from the LTE standard (Table 6.3.4.2.3-1 or 6.3.4.2.3-2), which is not "received" but prestored on the devices, Appx2320-2321; *see also* Appx1441; (2) a value representing the number of antenna ports on the base station, which is sent by a base station in the "transport block CRC attachment," Appx2287; Appx26536; Appx35129; (3) a "codebook index"; and (4) a value representing the number of "layers" in the data stream. Appx1447-1448; Appx26467; Appx35060; Appx2289-2290.

The device also computes the last two items—codebook index (3) and number of layers (4)—using four inputs: (a) another table from the LTE standard (Table 5.3.3.1.5-4 or 5.3.3.1.5-5), also prestored on the device, Appx2320-2321; *see also* Appx1441; (b) the number of antenna ports (again); (c) "precoding information" sent from the base station in the "DCI Format 2 message," Appx2288; Appx26545-26546; Appx35138-35139; and (d) a value representing

the number of "codewords," which the device computes using other values contained in the DCI Format 2 message. Appx2288-2289; Appx2321-2322; Appx26545-26546; Appx26549; Appx35138-35139; Appx35142.

This process is illustrated in the following diagram:




These undisputed facts refute infringement because no transmission "receive[d]" by an accused device contains a processing parameter. Rather, the processing parameters are computed by the device from combinations of

information prestored on it and information received by it through multiple transmissions.

This difference is meaningful because, as Optis's expert Dr. Mahon admitted, "constructing" a parameter does not "mean the same thing as" the claimed "receiving." Appx2389. ***First***, they differ in their ordinary meaning: "receiving" a whole product is not the same as receiving only some component parts that must then be combined with other components to construct the whole. *See* Appx2285-2286; Appx2291-2293; *see Network-1 Techs., Inc. v. Hewlett-Packard Co.*, 981 F.3d 1015, 1022 (Fed. Cir. 2020) ("Claim terms are generally given their ordinary and customary meaning[.]"). The '774 patent itself reinforces this: whereas asserted claim 6 recites "receiving a processing parameter," other unasserted claims recite "***determining*** a processing parameter." Appx354. Thus, had the inventor meant claim 6 to cover implementations where the device ***determines*** a processing parameter itself, as Apple's do, the inventor knew how to draft it that way. *See Enzo Biochem, Inc. v. Applera Corp.*, 599 F.3d 1325, 1333 (Fed. Cir. 2010). ***Second***, constructing and receiving a processing parameter also differ functionally: Wells explained without contradiction that Apple's approach is more "flexible" and "efficient" than transmitting a "dedicated" processing parameter. Appx2292-2294.

The court concluded, however, that the jury could find infringement based on Mahon's testimony that the received "precoding information" in the DCI Format 2 message (item (c) above) "contains at least one of a time delay, a phase rotation and a gain." Appx165. Mahon elaborated that the precoding information contains—or "includes" or "carries"—the processing parameters because the device "pulls out a gain and a phase rotation ***based upon*** what it receives on that DCI format 2" message. Appx1447; Appx1449; Appx1453. But that assertion is unsupported by the record and distorts the claim language. As explained, Apple's devices ***compute*** the processing parameters using not only the precoding information, but also other information in the DCI format 2 message ***and*** information from another message ***and*** two tables prestored on the device. Thus, no reasonable jury could have found that the precoding information alone includes, carries, or otherwise contains the processing parameters.

Contradictorily, Optis also argued that "the codebook index" (rather than the precoding information) "carries the gain and phase rotation information." Appx8378; *see also* Appx8377. That argument fares even worse. The codebook index is not "received" either; the device computes it using both prestored and received information. And as just explained, the codebook index is only one of the numerous inputs the device uses to compute the processing parameters.

### 2. DOE

In denying Apple's JMOL motion, the district court concluded that Mahon "properly incorporated by reference his earlier testimony into the DOE analysis" and "further expanded upon that analysis to show insubstantiality between the claims and the Accused Products." Appx167. But although an expert may "incorporate earlier testimony in order to avoid duplication," the expert must still establish that the DOE requirements are satisfied. *Paice LLC v. Toyota Motor Corp.*, 504 F.3d 1293, 1305-1306 (Fed. Cir. 2007). Mahon did not.

DOE "requires a showing that the difference between the claimed invention and the accused product or method was insubstantial or that the accused product or method performs the substantially same function in substantially the same way with substantially the same result as each claim limitation." *AquaTex Indus., Inc. v. Techniche Sols.*, 479 F.3d 1320, 1328 (Fed. Cir. 2007). The plaintiff must offer "particularized evidence that links the accused products to the patent on a limitation by limitation basis." *Motionless Keyboard Co. v. Microsoft Corp.*, 486 F.3d 1376, 1383 (Fed. Cir. 2007).

Mahon's testimony failed these requirements. First advancing a "function-way-result" theory, he initially argued that the "function" of "receiving a processing parameter" was "receiving a codebook index for the result of decoding the data properly on the phone." Appx1519-1520. But as explained above,

Apple's devices never "receiv[e] a codebook index"; they compute it. And Mahon's assumption that receiving the codebook index would be equivalent to receiving the processing parameters is unsupported because, as also explained, the codebook index is only one of multiple inputs that must be combined with other inputs prestored on the device or received over multiple messages through several steps to construct the recited processing parameters. Receiving a codebook index is thus a completely different function from "receiving a processing parameter." Appx2295.

Later, Mahon changed his asserted function to "carrying the ***processing parameter information*** to the phone." Appx1519-1520. That also fails because he did not explain what he meant by "processing parameter ***information***" or why it was substantially the same as the claimed "processing ***parameter***." *See Motionless Keyboard*, 486 F.3d at 1382 ("conclusory statements about equivalents" are insufficient). Moreover, as noted above, Apple's approach involves a very different function: computing parameters at the device, which is more flexible and efficient than transmitting dedicated parameters (or "processing parameter information," whatever that is).

As to the way, Mahon's way of "being carried on the DCI format 2 message," Appx1519-1520, simply repeats his new asserted function and thus fails for the same reason. As Wells testified without contradiction, "[t]he Apple

products do pretty much completely the opposite” of receiving processing parameters, namely, “comput[ing] th[e] processing parameter themselves.” Appx2295-2296. Neither Optis nor the district court explained how Wells was wrong.

On rebuttal, Mahon contradicted his chief DOE theory, asserting: “the … function … is customization of the signals that are coming to your phone”; the “way [is] [i]t applies a gain and a phase rotation”; and the “result” is that “your phone is able to decode those signals coming down [from the base station] to obtain that information properly.” Appx2550.

This fallback theory (which the district court apparently credited, *see* Appx167-168) fails for multiple reasons. First, it is directed not to the “receiving a processing parameter” limitation, but rather to claim 6 (or the patent itself) in its entirety. Mahon himself stated that “[t]he ’774 [patent] is directed towards using customization parameters that your phone sends up to the network to customize the signals that come down to your phone.” Appx2544; *see also* Appx2550-2551; Appx1442. But DOE “must be applied to individual elements of the claim, not the invention as a whole.” *AquaTex*, 479 F.3d at 1329 (quotation marks omitted). Nowhere did Mahon supply the particularized evidence required to show equivalence between Apple’s computation of processing parameters and the specific “receiving a processing parameter” element under his fallback theory.

Second, this DOE theory impermissibly vitiated the "receiving" term by eliminating it entirely and leaving no requirement for how the device obtains the processing parameter—whether by receiving, constructing, or otherwise—as long as the device eventually "applies" the processing parameter. *See Sage Prods., Inc. v. Devon Indus., Inc.*, 126 F.3d 1420, 1424 (Fed. Cir. 1997) (DOE "does not grant Sage license to remove entirely the 'top of the container' and 'over said slot' limitations from the claim"). Applying DOE to eliminate the "receiving" requirement was especially inappropriate because "receiving" is a simple, unambiguous term. *See id.* at 1425.

### C. The '332 "Floor(N/L)" Patent

Base stations send "control information" to mobile devices to tell them how to communicate with the base station. Appx1399-1400. The LTE network uses a system of "control channels" to transmit control information between the base stations. The '332 patent describes a technique that a mobile device may use to search for such control information using a specific mathematical operation. *See* Appx266. Asserted claim 6 recites:

> A ***user equipment*** (UE) for decoding control information, the UE comprising:
>
> a ***receiver for receiving*** a Physical Downlink Control Channel (PDCCH) from a base station at subframe k; and
>
> a ***decoder for decoding*** a set of PDCCH candidates within a search space of the PDCCH at the subframe k, wherein each of the set of

PDCCH candidates comprises 'L' control channel elements (CCEs),

wherein the 'L' CCEs corresponding to a specific PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located ***from a position given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation, wherein 'C' is determined as 'floor(N/L)'***, wherein 'N' represents a total number of CCEs in the subframe k, and

wherein $Y_k$ is defined by:

$Y_k=(A*Y_{k-1})\mathrm{mod}\ D$,

wherein A, and D are predetermined constant values.

Appx291-292. Asserted claim 7 contains the same relevant language. *Id.*

The district court erroneously held the claims patent-eligible and literally infringed; they are neither.

**1. Eligibility**

The asserted '332 claims are patent-ineligible because they are directed to an abstract idea—a mathematical formula—and their non-formula elements were "well-understood, routine, conventional activities previously known to the industry." *Alice Corp. Pty. v. CLS Bank Int'l*, 573 U.S. 208, 218-219, 225 (2014) (quotation marks omitted).

The '332 patent fails at *Alice* step one because it is directed solely to a mathematical formula. *DDR Holdings, LCC v. Hotels.com*, 773 F.3d 1245, 1256 (Fed. Cir. 2014) ("mathematical algorithms … are abstract ideas"). Optis's expert conceded that the "focus of the invention" is using the equation (which he called "a

multiplicative congruential pseudo-random number generator") to calculate the starting position of the data search. Appx7451(¶128).

The specification reinforces that the claims are directed to a mathematical formula: "The basic purpose of each embodiment of the present invention is to generate a different value" for the starting point of the data search, Appx286, i.e., to use the formula. It also explains (via the priority application, which is incorporated fully, Appx282) that "[t]he present invention suggests generation of a random number" using "a famous random number generation method." Appx7448.

The district court, however, concluded that the claims were "not abstract" because they were supposedly "directed to applying the equation in a way that offers a technological improvement." Appx60. The court offered no supporting analysis. *See id.*; Appx67.

For its part, Optis argued that the formula provides "a specific solution" to "the prior art problem" of how to "efficiently … receiv[e] control information through" a PDCCH. Appx7619 (quotation marks omitted). But Optis's expert conceded that the claims' focus is the mathematical formula (Appx7451(¶128))—a fact the district court disregarded. And even if the claim represented an advance over prior art, its only advance would be the equation itself, which remains abstract. *Affinity Labs of Texas, LLC v. DirectTV, LLC*, 838 F.3d 1253, 1257, 1263

(Fed. Cir. 2016) (patent ineligible because the "essential advance" was the "abstract idea"); *Dropbox, Inc. v. Synchronoss Techs., Inc.*, 815 F. App'x 529, 534 (Fed. Cir. 2020) ("abstract idea to which a claim is directed cannot supply the inventive concept"). In any event, the '332 patent's formula was not inventive at all; the applicants described it as a "famous" formula, which has been used since 1949. Appx7440-7441; Appx7448.

The asserted claims also fail at *Alice* step two (which the court did not reach) because their non-formula elements (separately or together) lack any inventive concept. Those elements—the UE, receiver, and decoder—were indisputably well-understood, routine, and conventional. *See* Appx282. So were the concepts of control information and a device searching for that information in the particular channel at issue. Indeed, before the '332 patent, a standard-setting body recognized the problem of how a device would efficiently search the PDCCH for control information and concluded that the search's starting position would be determined by a random-number-generating "hashing" function. Appx282; Appx7435-7436.

As a named inventor conceded: "[W]hat we are proposing is nothing new really. … What we are proposing is to use what is well known equation as it is to achieve good randomization properties." Appx7418. No "inventive concept" was added. *See Parker v. Flook*, 437 U.S. 584, 585-586, 594 (1978) (computerized

method using mathematical formula to adjust alarm limits patent-ineligible because "the formula itself was an abstract idea and the computer implementation was purely conventional").

### 2. Infringement

Separately, Optis failed to adduce substantial evidence of literal infringement (and did not assert DOE). The code in Apple's chips undisputedly does not use the claimed "floor(N/L)" calculation, but rather uses a "shift" calculation. Appx2331-2332; Appx1560; Appx1563; Appx2426-2428. Optis's expert, Dr. Madisetti, asserted that Apple's "shift" calculation "implements," "perform[s]," or "carrie[s] out" the required floor(N/L) calculation. Appx1560; Appx1563; Appx2510; Appx2514. But that was insufficient because "[w]here a claim does not read on an accused device ***exactly***, there can be no literal infringement." *Johnston v. IVAC Corp.*, 885 F.2d 1574, 1580 (Fed. Cir. 1989); *see Exergen Corp. v. Kaz USA, Inc.*, 725 F. App'x 959, 968-969 (Fed. Cir. 2018). The claimed floor(N/L) operation uses arithmetic division—"N" divided by "L" —whereas Apple's shift operation "shifts" "the 0s and 1s" of binary code "right or … left" by the specified number of "position[s]." Appx2331-2332; Appx2409-2410; Appx2426-2430. Apple's engineer witness, who wrote the code in the Intel chips used by Apple's products, explained without contradiction that the shift operation is not only different from, but also far more efficient than, the claimed floor(N/L)

operation because the shift "does something in one step compared to any other operation, which can take multiples or tens of steps." Appx2409-2410. Apple's expert, Mr. Lanning, explained that the claimed floor(N/L) operation requires a device to perform "***36 million more [processing] steps*** … than" the shift operation "every hour," and all those additional steps cause battery "life … to go down tremendously." Appx2431; *see also* Appx2428-2430; Appx2438-2439; Appx2331.

Optis argued that the shift operation yields the same ***answer*** as the floor(N/L) operation, *see* Appx8372; Appx2513, but "[m]erely producing that same result in a different way does not suffice" to prove literal infringement. *Microsoft Corp. v. GeoTag, Inc.*, 817 F.3d 1305, 1313-1315 (Fed. Cir. 2016).

### D. The '284 "Redundancy Version" Patent

The '284 patent references "joint encoding" for control information, whereby a single control-information field communicates two "parameters" simultaneously, Appx1402; Appx295: (1) a "transport format" parameter telling the mobile device "how the data is assembled"; and (2) a "redundancy version" parameter telling the device "how [to] correct errors … in the data," Appx1402. The patent may achieve its joint encoding through a lookup table of control index values, each referring to a transport-format value and a redundancy-version value. Appx1402-1403; Appx1407.

Asserted claim 1 recites:

> A mobile terminal for use in a mobile communication system, the mobile terminal comprising:
>
> a receiver unit for receiving a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal,
>
> a processing unit for determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and
>
> a transmitter unit for transmitting the protocol data unit on at least one physical radio resource using the transport format and the redundancy version of the protocol data unit indicated in the received control channel signal,
>
> wherein the control channel signal received within said sub-frame comprises a control information field, in which the transport format and the redundancy version of the protocol data unit are jointly encoded,
>
> wherein the processing unit is further configured for the determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field, ***wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit*** and ***a second subset of the values***, different from the first subset of the values, ***is reserved for indicating the redundancy version for transmitting the user data***, and
>
> wherein ***the first subset of the values contains more values than the second subset of the values***.

Appx317-318. Asserted claims 14 and 27 contain the same relevant language.

Appx318-319. At the *Markman* stage, the court "determine[d] that 'reserved for

indicating' has its plain and ordinary meaning without the need for further construction." Appx33.

The evidence showed indisputably that Apple's products use the opposite configuration from the claims: the accused "first subset" of values indicating transport format has ***fewer*** (not "more") values than the "second subset" indicating redundancy version. This is clear from the "modulation and coding scheme" (MCS) index found in Technical Specification 36.213 of the LTE standard (Appx35210-35211):

**Table 8.6.1-1: Modulation, TBS index and redundancy version table for PUSCH**

| MCS Index $I_{MCS}$ | Modulation Order $Q_m'$ | TBS Index $I_{TBS}$ | Redundancy Version $rv_{idx}$ |
|---|---|---|---|
| 0 | 2 | 0 | 0 |
| 1 | 2 | 1 | 0 |
| 2 | 2 | 2 | 0 |
| 3 | 2 | 3 | 0 |
| 4 | 2 | 4 | 0 |
| 5 | 2 | 5 | 0 |
| 6 | 2 | 6 | 0 |
| 7 | 2 | 7 | 0 |
| 8 | 2 | 8 | 0 |
| 9 | 2 | 9 | 0 |
| 10 | 2 | 10 | 0 |
| 11 | 4 | 10 | 0 |
| 12 | 4 | 11 | 0 |
| 13 | 4 | 12 | 0 |
| 14 | 4 | 13 | 0 |
| 15 | 4 | 14 | 0 |
| 16 | 4 | 15 | 0 |
| 17 | 4 | 16 | 0 |
| 18 | 4 | 17 | 0 |
| 19 | 4 | 18 | 0 |
| 20 | 4 | 19 | 0 |
| 21 | 6 | 19 | 0 |
| 22 | 6 | 20 | 0 |
| 23 | 6 | 21 | 0 |
| 24 | 6 | 22 | 0 |
| 25 | 6 | 23 | 0 |
| 26 | 6 | 24 | 0 |
| 27 | 6 | 25 | 0 |
| 28 | 6 | 26 | 0 |
| 29 | reserved | | 1 |
| 30 | | | 2 |
| 31 | | | 3 |

The table's third column ("TBS" or "transport block size" index) indicates the "transport format," and thus corresponds to the claims' "first subset of the values [that] is reserved for indicating the transport format." That "first" subset lists 29 values (0-26, with values 10 and 19 used twice). The fourth column indicates the "Redundancy Version" and corresponds to the claims' "second subset of the values [that] is reserved for indicating the redundancy version." That "second" subset has 32 values—0 for the first 29 rows and 1, 2, or 3 for the final three rows. Consequently, in Apple's products, the first subset (the "TBS" column) has 29 values, which is ***fewer*** than the second subset (the "Redundancy Version" column), which has 32—the opposite of the claims' express requirement. *See* Appx2070-2073; Appx2386-2387. Indeed, Optis's expert Mahon admitted: "There are more redundancy versions explicitly listed" "than transport format versions." Appx1515.

That admission is fatal to Optis's infringement case, but the district court improperly allowed Optis to argue a new claim construction to the jury. Optis redefined the claim by arguing that the second subset of values is not those reserved for indicating the redundancy version (as the claim requires), but rather is those values "reserved for when the redundancy version ***changes***." Appx2663-2664; Appx1423-1424; Appx2554. Under this construction, the second subset had

only 3 values, namely, the last three rows where the "Redundancy Version" values are 1, 2, or 3. Appx1421-1422.

Apple objected. Appx2556-2557 ("What Dr. Mahon is now doing is asking the jury to do claim construction and to do it in the wrong way."). The court overruled the objection, freeing Optis to argue a new claim construction to the jury. *Id*. Apple renewed its objection after trial, Appx8316; the court denied the motion without addressing the issue, *see* Appx171-172.

"[T]he construction of a patent, including terms of art within its claim, is not for a jury but exclusively for the court to determine." *Teva Pharms. USA, Inc. v. Sandoz, Inc.*, 574 U.S. 318, 321 (2015). Once it became clear that Optis was seeking to construe the claims controversially, the ***court*** should have resolved the issue rather than leaving it to the jury. *See O2 Micro Int'l Ltd. v. Beyond Innovation Tech. Co.*, 521 F.3d 1351, 1362 (Fed. Cir. 2008) ("the parties' arguments regarding the meaning and legal significance of the 'only if' limitation were improperly submitted to the jury"). The court compounded this error by twice refusing to allow Apple to submit evidence that Optis's new construction contradicts the file history. Appx2068-2069; Appx2117-2118; *see* Appx25857-25858.

Moreover, whether considered a matter of claim construction or evidentiary sufficiency, Optis's contention cannot support an infringement judgment. The

claims do not invite the reader to define the two "subsets" at will; they specify that the first indicates transport format, while the second indicates redundancy version. Yet Optis's theory limited the second subset only to redundancy versions of 1, 2, or 3, excluding redundancy versions of 0. Appx2554. As Mahon admitted, "nowhere" does "the claim language" limit the second subset of values to "chang[ing]" redundancy versions. Appx2386-2387.

The district court's discussion consists only of stating that Mahon "provided substantial evidence to support a finding that 'the first subset of the values contains more values than the second subset of the values.'" Appx172. All the court cited was Mahon's testimony that, under his belated claim construction, the second subset has only three values, because only then is the redundancy version "changing." Appx171-172 (citing Appx1417-1420). As explained, that evidence does not meet the limitation's express requirements.

Optis—though not the district court—sought to support its belated infringement theory with an embodiment and a related statement during prosecution. *See* Appx8319; Appx1421-1422; Appx312(Table 3); Appx25857. Of course, that only confirms that the parties had a claim-construction dispute that the court, not the jury, should have resolved. Moreover, Optis cannot rely on the specification and prosecution history—much less a single embodiment therein—to construe the claims differently from their plain language (since Optis did not assert

lexicography or disavowal). *GE Lighting Sols., LLC v. AgiLight, Inc.*, 750 F.3d 1304, 1308-1309 (Fed. Cir. 2014) ("the specification and prosecution history only compel departure from the plain meaning in two instances: lexicography and disavowal"); *Rolls-Royce, PLC v. United Techs. Corp.*, 603 F.3d 1325, 1334 (Fed. Cir. 2010) ("Although reluctant to exclude an embodiment, this court must not allow the disclosed embodiment to outweigh the language of the claim ….").

### E. The '833 "Mapping" Patent

Control signals indicating acknowledgment (ACK) or non-acknowledgment (NACK) travel from the mobile device to the base station and report whether the device received the base station's prior communication and how to communicate with the device. The '833 patent discloses "a method of transmitting uplink signals by efficiently arranging ACK/NACK signals and other control signals in a resource region considering priority among them." Appx368. The patent is generally directed to a specific manner of combining the different signal types ("multiplexing"), and then writing, or "mapping," that information to a table called a "2-dimensional resource matrix" for transmission. Appx370-371.

The court erred both as to claim construction and evidentiary sufficiency.

#### 1. Claim construction

Asserted claim 8 states:

A mobile station for transmitting uplink signals comprising control signals and data signals in a wireless communication system, the mobile station comprising:

a processor serially multiplexing first control signals and data signals, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals;

the processor mapping the multiplexed signals to a 2-dimensional resource matrix comprising a plurality of columns and a plurality of rows, wherein the columns and the rows of the 2-dimensional resource matrix correspond to single carrier frequency divisional multiple access (SC-FDMA) and subcarriers for each SC-FDMA symbol, respectively, wherein a number of columns of the 2-dimensional resource matrix corresponds to a number of SC-FDMA symbols within one subframe except specific SC_FDMA symbols used for a reference signal, and wherein the multiplexed signals are mapped from the first column of the first row to the last column of the first row, the first column of the second row to the last column of the second row, and so on, until all the multiplexed signals are mapped to the 2-dimensional resource matrix; and

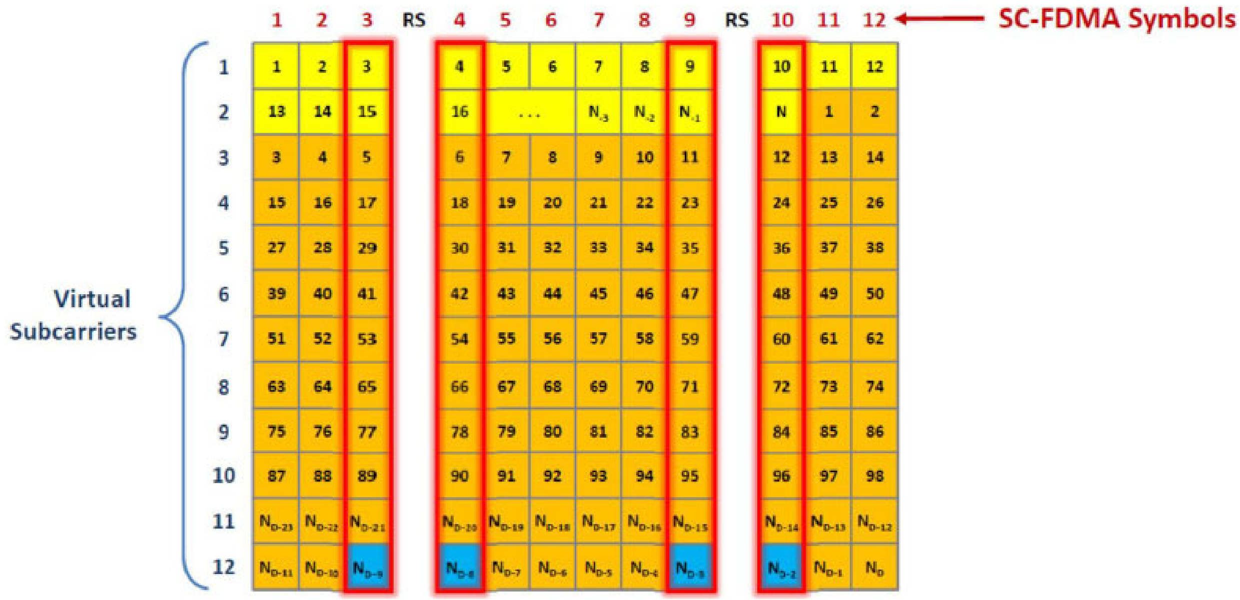
the processor mapping ACK/NACK control signals to specific columns of the 2-dimensional resource matrix, wherein the specific columns correspond to SC-FDMA symbols right adjacent to the specific SC-FDMA symbols, ***wherein the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix from the last row of the specific columns***.

Appx371.

In a prior case, *Optis Cellular Tech., LLC v. Kyocera Corp.*, No. 2:16-cv-0059 (E.D. Tex.), Optis admitted that the emphasized limitation ("mapped … from the last row") means the ACK/NACK signals are mapped row-by-row, ***beginning*** from the last row of the matrix and moving toward the first row. Appx7299-7300.

Apple advanced Optis's *Kyocera* interpretation. The district court rejected that view in both *Kyocera* and here, construing the limitation to be satisfied if ACK/NACK signals "corresponding" to "some multiplexed signals" in the matrix's "last row … are mapped," regardless of whether the mapping begins "from" the last row or not. *Kyocera*, 2017 WL 541298, at *19 (E.D. Tex. Feb. 9, 2017); Appx53-54; *see* Appx2624-2625. Optis was right the first time; the court was wrong.

The court reasoned that "the claim language itself does not mandate that the overwriting must start in the last row." *Kyocera*, 2017 WL 541298, at *19. That reasoning, however, begs the question. Context is "highly instructive," *Phillips v. AWH Corp.*, 415 F.3d 1303, 1314 (Fed. Cir. 2005) (en banc), and although in some contexts the word "from" just indicates a place and not a starting point, ***here*** the full description of the mapping process shows that the claim uses "from" to indicate the starting point of a mapping sequence. Begin with the following illustration, which Optis submitted in *Kyocera*:




Appx6251. According to claim 8, the multiplexed control and data signals are mapped row-by-row, starting with the "first control signals" (yellow cells) in the first row until all control signals are mapped, and then continuing with the data signals (orange cells), until the last row. Appx371; Appx7322-7324(¶¶51-52, 55). Then, the claimed ACK/NACK signals (blue cells) overwrite the data signals adjacent to the reference symbols (white "RS" columns). Appx371; Appx7323(¶52). If, in this example, there are more than four ACK/NACK signals, the question arises: where are the additional ACK/NACK signals mapped?

As Optis recognized in *Kyocera*, based on its own expert's testimony, the answer is that "the claim language requires mapping 'from' the last row of those columns, so that after mapping the four blue square[s] shown above[,] additional ACK/NACK [signals] could be mapped to rows above (e.g., rows 11, 10, and so on, as needed)." Appx7300; *see* Appx7320-7321(¶45). Apple's expert Wells

agreed, stating that a skilled artisan "would understand that the plain meaning for 'from' is a beginning or starting point." Appx7321(¶46). If the applicants had intended "from" to mean "in," as the court concluded, they could easily have used "in" instead. *See id.*

Apple's construction is confirmed by the prosecution history, which the court ignored. The applicants added the limitation, including the phrase "from the last row," to overcome a prior-art rejection. Appx7350-7351; Appx7354; Appx7358. The applicants explained: "By making the ACK/NACK control signals overwrite some of the multiplexed signals from the last row," the claim "can ***reduce*** the probability that the ***first*** control signals are overwritten by the ACK/NACK signals." Appx7358. As Wells explained, a skilled artisan would have understood that, to "reduce the probability" of overwriting the "first control signals," the ACK/NACK mapping would need to begin in the last row and proceed row-by-row toward the first row; because the number of "first control signals" is variable and ***those*** signals are mapped row-by-row starting from the ***first*** row, beginning the ACK/NACK mapping "as far away from the control signals as possible"—starting from the last row and moving forward—is the best way "to ensure that the control signals are not overwritten." Appx7322-7324(¶¶50-55); *see* Appx371. Indeed, there is no other reason—certainly Optis did not identify one—for the claim to single out ACK/NACK mapping in the last row.

By contrast, the court's construction improperly renders the phrase "from the last row" arbitrary and meaningless. *See Aristocrat Techs. Australia Pty Ltd. v. International Game Tech.*, 709 F.3d 1348, 1356 (Fed. Cir. 2013).

Optis did not attempt to prove that Apple's products embody claim 8 as properly construed. Thus, because the court's "incorrect claim construction … remove[d] from the jury a basis on which the jury could reasonably have reached a different verdict, the verdict should not stand." *Network-1*, 981 F.3d at 1022 (quotation marks omitted).

### 2. Infringement

Even under the district court's erroneous construction, Optis did not prove infringement because it adduced no evidence that Apple's products map the signals row-by-row to a 2-dimensional resource matrix. Rather, the evidence showed that Apple's products do the opposite: they map the signals ***column-by-column***. (Optis did not assert DOE.)

As Wells explained with respect to both Intel-based and Qualcomm-based Apple products, the hardware code specifies that the multiplexed control and data signals are mapped column-by-column, not row-by-row as claim 8 requires. *See, e.g.*, Appx2406; Appx2310-2311. Dr. Josiam, a former Intel engineer, confirmed as much for the Intel-based products. *See, e.g.*, Appx2218-2219; Appx2225-2227.

The district court cited Madisetti's assertion that Wells had confused the "transmission step" with the "mapping step." Appx170 (citing Appx2520-2523). That is incorrect; Wells was clearly referring to the mapping step. *See* Appx2305-2311. At his deposition, Madisetti himself admitted that Apple's products map column-by-column, and not row-by-row as the claim requires. Appx1659 ("they are mapped column-by-column").

The district court identified no evidence that Apple's products actually map row-by-row. The court relied on Madisetti's testimony regarding "the LTE standard," Appx169-170, but he simply assumed that the LTE standard required row-by-row mapping; neither he nor the court cited any evidence showing that it actually did, *see, e.g.*, Appx1834, *cited in* Appx170. On the contrary, the only testimony that examined the LTE standard established that it does not mandate row-by-row mapping. Appx2036-2046 (The "LTE standard tells us what the baseband chip needs to do in order to connect and operate with [the] LTE network …. But it doesn't tell us how we must do it."). Consequently, the standard could show infringement only if Optis proved that the "patent covers every possible implementation of [the] standard," *Fujitsu Ltd. v. Netgear Inc.*, 620 F.3d 1321, 1328 (Fed. Cir. 2010), but Optis did not prove that, and the court did find that it had.

Next, the court relied on Madisetti's analysis of the Apple products' "source code." Appx170; *see* Appx1576-1578. But the "code" Madisetti discussed was not the functional hardware code; it was merely programmer comments. *See* Appx26713 (citing PX0090 at Q1OPWAPP00066SC0001028, line 91); Appx8306(¶804) (Optis expert Mr. Jones describing line 91 as a "comment"). And those comments indicate only that Apple's products map the multiplexed control and data signals to a matrix, without specifying whether that mapping is row-by-row or column-by-column. *Id*. As noted above, the hardware code—which controls how Apple's products actually work—specifies column-by-column mapping. An expert's wholly inaccurate description of evidence cannot support a verdict. *Brooke Grp. Ltd. v. Brown & Williamson Tobacco Corp.*, 509 U.S. 209, 242 (1993) ("When an expert opinion is not supported by sufficient facts to validate it in the eyes of the law, or when indisputable record facts contradict or otherwise render the opinion unreasonable, it cannot support a jury's verdict.").

The court also cited Madisetti's assertion that, in the Apple products, "the map is constructed row-by-row." Appx2520-2523; Appx170. But shorn of Madisetti's mistaken reliance on the LTE standard and the source code, this was but a conclusory and therefore insufficient assertion. *See supra* p.18.

Finally, the court cited Madisetti's assertion that "Apple tests its devices … in almost 30 different locations in the U.S." Appx1834; Appx170. That is

immaterial because it did not address how Apple's products map the signal information.

### F. The '557 "Selecting Unit" Patent

The '557 patent is generally "directed to technology for allowing a mobile communication device to report control information to the base station using the Random Access Channel ('RACH')." Appx39. Asserted claim 1 recites:

> A ***mobile station apparatus comprising***:
>
> a ***receiving unit*** configured to receive control information;
>
> a ***selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped*** and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts; and
>
> a ***transmitting unit*** configured to transmit the selected sequence,
>
> wherein a position at which the predetermined number of sequences are partitioned is determined based on the control information, and a number of sequences contained in each of the plurality of groups varies in accordance with the control information.

Appx338. Asserted claim 10 contains the same relevant language. *Id.*

### 1. Claim 1's Indefiniteness

#### *a. Claim 1's insufficient structure*

"The standard" test for whether a claim is subject to 35 U.S.C. §112, ¶6 "is whether the words of the claim are understood by [skilled artisans] to have a sufficiently definite meaning as the name for structure." *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1349 (Fed. Cir. 2015) (en banc). "When a claim term lacks the word 'means,' … § 112, para. 6 will apply if the challenger demonstrates that the claim term fails to recite sufficiently definite structure or else recites function without reciting sufficient structure for performing that function." *Id.* (quotation marks omitted).

Claim 1's "selecting unit" language lacks the requisite recitation of structure. "[T]he word 'unit' … does not, standing alone, connote any particular structure." *Diebold*, 899 F.3d at 1301. Rather, like "module," "mechanism," "element," and "device," "unit" is a "generic … nonce word[] … that is tantamount to … means.'" *Williamson*, 792 F.3d at 1350.

"Selecting" does not impart sufficient structure because "selecting unit" still lacks a "commonly understood meaning and is not generally viewed by one skilled in the art to connote a particular structure." *Media Rights Techs., Inc. v. Capital One Fin. Corp.*, 800 F.3d 1366, 1372 (Fed. Cir. 2015); *see Williamson*, 792 F.3d at 1351 ("The prefix 'distributed learning control' does not impart structure into the

term ‘module.’”). Apple’s expert explained: “Not only does [‘selecting unit’] have various meanings in different fields of study, but also this is not a term of art that has a well understood single meaning within the field of telecommunications.” Appx7126-7127(¶43); *see* Appx7161 (prior art description of selecting unit); Appx7187 (same); Appx7201 (same); Appx7237 (same). Nor do the specification and prosecution history impart “any structural significance to the term.” *Williamson*, 792 F.3d at 1351.

Optis’s conflicting evidence confirmed that “selecting unit” lacks known or definite structure. Optis submitted prior art giving a different meaning to “selecting unit.” *See* Appx6197. Optis vacillated over whether a “selecting unit” must be implemented in hardware or software. *See* Appx5034. And Optis identified a “preamble generator” as an example selecting unit, *id.*, only for its expert to disagree, Appx1612 (limitation “doesn’t require that the sequences are generated”); *accord* Appx1821.

The district court erroneously found the claim definite based on its incorrect construction in *Optis Wireless Technology, LLC v. ZTE Corp.*, 2016 WL 1599478, at *39-40 (E.D. Tex. Apr. 20, 2016). Appx45-46. There, the court reasoned that the claim says the selecting unit “achieve[s]” its “objective” of “select[ing] a sequence” by “‘randomly’ selecting from a ‘plurality of sequences’ that are ‘contained in one group of a plurality of groups’ of a specific structure” and then

transmitting the selected sequence "via the 'transmitting unit.'" *ZTE*, 2016 WL 1599478, at *40.

But that claim language still is insufficient. First, it merely catalogs functions; it does not specify any algorithm or physical structure showing how the selecting unit ***works***. Second, that language describes "inputs and outputs at a very high level," rather than "how the [disputed limitation] interacts with other components." *Williamson*, 792 F.3d at 1351. Third, the claim's recitation of a "connect[ion]" between the selecting unit and the transmitting unit, *ZTE*, 2016 WL 1599478, at *40, is also too high-level to impart any particular structure. Finally, the court thought "the fundamental structure of the unit [i]s a circuit," *id.* at *41, but that is unsupported; as noted above, Optis could not decide whether the "selecting unit" was hardware or software.

#### ***b. The specification's insufficient structure***

Because "selecting unit" is subject to § 112 ¶6, "the specification [must] disclose[] sufficient structure that corresponds to the claimed function." *Williamson*, 792 F.3d at 1351. This involves a "two-step process": (1) "identify the claimed function"; (2) "determine what structure, if any, disclosed in the specification corresponds to the claimed function." *Id.* at 1351-1352. "Structure disclosed in the specification qualifies as corresponding structure" only "if the intrinsic evidence clearly links or associates that structure to the function recited in

the claim," i.e., a skilled artisan must be "[]able to recognize the structure in the specification and associate it with the corresponding function in the claim." *Id.* at 1352.

Claim 1 fails to meet this standard and is therefore indefinite. The claimed function is randomly selecting a sequence from a plurality of sequences, but the specification fails to "disclose an algorithm for performing [that] function." *Williamson*, 792 F.3d at 1352; *see Rain Computing, Inc. v. Samsung Elecs. Am., Inc.*, 989 F.3d 1002, 1006 (Fed. Cir. 2021). None of Optis's evidence supplies the structure.

First, Optis argued that the claim language "details a specific arrangement of sequences, the grouping of the sequences, and the selection of a sequence from one of the groups." Appx5034. But again, that language merely specifies functions, describing ***what*** the unit selects and what it selects ***from***, not ***how*** it selects or what ***structure*** it uses to do so. *See* Appx338.

Next, Optis argued that embodiments depict how the unit "interacts with the other components in the system in Figs. 1 and 10." Appx5034. But those figures merely put boxes around functions, without identifying any structure by which the functions are performed, Appx320-338; Appx7133-7134(¶52); *see ePlus, Inc. v. Lawson Software, Inc.*, 700 F.3d 509, 518-519 (Fed. Cir. 2012); *Fiber, LLC v. Ciena Corp.*, 792 F. App'x 789, 794 (Fed. Cir. Nov. 21, 2019).

Finally, Optis asserted that the embodiments described "complex mathematical equations that may be used to generate sequences," Appx5034, but this claim term recites ***selecting*** sequences, not generating them, *see* Appx7122-7123(¶35); Appx7129-7138(¶¶49-51, 54), a point Optis's expert acknowledged, Appx1612. Therefore, the specification fails to "clearly link" the disclosed algorithms to the identified function. *B. Braun Med., Inc. v. Abbott Labs.*, 124 F.3d 1419, 1424 (Fed. Cir. 1997).

### 2. Infringement of claims 1 and 10

#### *a. Literal infringement*

Optis failed to prove that claims 1 and 10 read on Apple's products in multiple respects.

First, Apple's products do not "select a sequence from a plurality of sequences." Apple's products undisputedly select an index and use that index to generate a sequence on the fly. Appx8364. And an index undisputedly is a single number, not a sequence, which is an ordered set of numbers. Appx2344-2345.

The district court denied Apple's JMOL motion based on Madisetti's testimony that "you can select a sequence by selecting the sequence index." Appx1821; Appx158; *see also* Appx2530-2532. That testimony was conclusory and therefore insufficient to sustain a verdict. *Supra* p.18.

Second, there is no evidence that Apple's products "generate[]" the specified plurality of sequences "from a plurality of base sequences," as required. Apple's expert Lanning and engineer Josiam testified without contradiction that the source code in Apple's products does not use a base sequence (much less a plurality of them) to generate a sequence, but instead generate the sequence from one (single-value) parameter. Appx2347-2354; Appx2413-2418; Appx2238-2242. Madisetti ignored that source code, again offering nothing but conclusory statements and purported embodiments in the specification, not the claims themselves. *See* Appx1632; Appx1821; Appx2530-2532.

The court, however, determined that Madisetti supplied evidence that Apple's products "operate according to the relevant portions of the LTE standard" and that the standard discloses the claim limitation. Appx157. But as just explained, Apple's products themselves do not generate the claimed plurality of sequences from a plurality of base sequences. *See Godo Kaisha IP Bridge 1 v. TCL Commc'n Tech. Holdings Ltd.*, 967 F.3d 1380, 1384 (Fed. Cir. 2020) (where "claim might not cover all implementations of an industry standard," "infringement must be proven by comparing the claims to the accused products"). Moreover, Madisetti's only testimony that the claim reads on the LTE standard was likewise conclusory. Appx1820.

Together, these differences between Apple's products and the claim limitations are undisputedly significant. Lanning testified that the process used by Apple's products "is a lot more efficient for the processor" because, unlike the claimed invention, Apple's products are "not busy doing a lot of busy work[] and [they're] not using all these memory locations." Appx2417; Appx2353-2354. Apple's products "just figur[e] out what sequence need[s] to be transmitted, transmit it, and then, bam, it's gone out to the antenna, and there's no storage required." Appx2417. Josiam agreed. Appx2238-2242 ("[I]t is incredibly efficient to generate just one sequence."). Lanning and Josiam explained that Apple's approach results in its devices using less memory, having longer battery life, and not "get[ting] too hot." Appx2416-2418; Appx2241-2242; Appx2038-2039.

#### *b. DOE*

Optis also failed to prove DOE infringement of claims 1 and 10. The district court concluded that Madisetti had "properly incorporated by reference his earlier testimony" regarding literal infringement "into the DOE analysis," and that he had "expanded upon that analysis to show insubstantiality between the claims and the Accused Products." Appx161. That is wrong. Once again, incorporating earlier literal-infringement testimony does not excuse the expert from showing that the DOE's requirements are satisfied, *see supra* p.17, and Madisetti failed to.

First, although Madisetti purported to present "a function-way-result analysis," his discussion was incoherent because he identified the same material for each. He said that "the process of selecting a sequence" is a "way." Appx1824. Then he said it was a way "by which this function is met," and the context indicates that "this function" referred to "selecting a sequence." Appx1823-1824; *see also* Appx1821. And then he said that the "result … is selecting the sequence." Appx1824. Such confusing and circular testimony did not provide the requisite analysis. *See supra* pp.17-18.

Second, Madisetti's testimony is devoid of the requisite particularized evidence showing a similar function, way, and result among the claims and the accused products. *See supra* p.17. His only statement to that effect was his conclusory rebuttal remark that "[t]here's no difference" between the claims' function of "generating the sequences in advance and storing them" and Apple's products' "using an index and generating the sequence on the fly." Appx2531-2532. Once again, that *ipse dixit* is insufficient. *See supra* p.18.

Further, Apple's witnesses supplied undisputed testimony showing the significant differences between Apple's products and the claims. As noted, they explained that Apple's products select a sequence index to generate only a single sequence and to generate it from parameters, not base sequences—and that Apple's approach is markedly superior to the claimed process of selecting a sequence from

a plurality of sequences generated from a plurality of base sequences. *See supra* pp.44-46; Appx2418-2420.

Madisetti's thin DOE testimony contrasts sharply with the testimony in *Paice*, on which Optis relied. There, the expert "demonstrated and explained operation of an actual accused device to the jury, linked that demonstration and explanation to the function of the" claimed invention, supplied "similar[]" testimony "with respect to linking the way and result prongs," and explained "the insubstantiality of the differences" between the accused and claimed devices. 504 F.3d at 1306-1307. Madisetti's testimony did not come close.

**3. No U.S. use of claim 10**

Finally, Optis failed to prove that all steps of claim 10's method were used in the United States. *See Finjan, Inc. v. Secure Computing Corp.*, 626 F.3d 1197, 1206 (Fed. Cir. 2010). Madisetti testified only generically that Apple tested "the LTE standard" domestically. Appx1830-1831; Appx1833-1834. The standard can be implemented without meeting claim 10's "plurality of groups" requirement, Appx26378-26379(§5.1.1) ("if Random Access Preambles group B exists …"); Appx26379-26380(§5.1.2) (same), but Optis supplied no evidence that Apple or any Apple customer specifically performed claim 10's requirements in the United States. *See* Appx26565-26582 (transmissions of group sequences are from unidentified sources); Appx160.

### G. Each Error In Part II.B-F Independently Requires Vacatur

Any one of the errors shown in Part II.B-F compels vacatur of the entire judgment because the general infringement verdict makes it impossible to know whether the first jury relied on an erroneous or unsupported theory in rendering its infringement verdict, *see supra* pp.10-11, and the general damages verdict makes it impossible to remit the damages award to any patents permissibly found infringed.

As the district court correctly recognized, courts "must set aside a general verdict if the jury was told it could rely on any of two or more independent legal theories, one of which was defective." *i4i Ltd. P'ship v. Microsoft Corp.*, 598 F.3d 831, 849 (Fed. Cir. 2010); *see* Appx184. Accordingly, if the Court sustains any of Apple's legal challenges—claim construction, indefiniteness, or patent-ineligibility—the entire infringement judgment must unquestionably be vacated.

With respect to challenges to the sufficiency of the evidence, the court stated a different rule: a "general verdict will be upheld 'if there was sufficient evidence to support ***any*** of the plaintiff's alternative factual theories.'" Appx184 (quoting *i4i*, 598 F.3d at 849) (emphasis original). If the court intended that statement to apply across multiple patents, rather than simply across multiple theories of infringement for the same patent, it overstated *i4i*'s holding. But either way, the court's position contradicts Supreme Court precedent.

First, *i4i*'s statement applies only to general verdicts involving "alternative factual theories" regarding a ***single*** patent. 598 F.3d at 849. The plaintiff, i4i, asserted contributory and induced infringement of one patent, and this Court held that the general verdict would be upheld if "there was sufficient evidence to support either of [those] theories." *Id.* at 850. The cases on which *i4i* relied involved the same situation: a general verdict covering alternative factual bases regarding a single claim. *See Northpoint Tech., Ltd. v. MDS Am., Inc.*, 413 F.3d 1301, 1305, 1311-1312 (Fed. Cir. 2005) (under Eleventh Circuit law, declaring that jury's anticipation finding would be upheld if "at least one of the prior art references was sufficient to prove anticipation" because the references were merely "separate factual bases" for "the single legal theory of anticipation"); *Walther v. Lone Star Gas Co.*, 952 F.2d 119, 125-126 (5th Cir. 1992) (affirming verdict of age discrimination notwithstanding insufficiency of "statistical evidence" because "the evidence [of age discrimination] as a whole was sufficient"). Here, by contrast, the court used a single general-verdict question for multiple ***patents***, i.e., entirely separate ***claims*** of infringement. Nothing in *i4i*, *Northpoint*, or *Walther* indicates that their rule applies in such a situation. After all, a jury cannot rely on a theory of infringement of one patent to find infringement of another patent.

Second, and in the alternative, the rule for evidentiary challenges to general verdicts articulated in *i4i*, *Walther*, and *Northpoint* contradicts *Wilmington Star*

*Mining Co. v. Fulton*, 205 U.S. 60, 79 (1907), which held that, in civil cases, a general verdict covering multiple factual bases cannot be sustained if even one lacks sufficient evidence. *See also Muth v. Ford Motor Co.*, 461 F.3d 557, 564 (5th Cir. 2006); *Watson v. Johnson Mobile Homes*, 284 F.3d 568, 574 (5th Cir. 2002). *Walther* erroneously relied on a ***criminal*** case, *Griffin v. United States*, 502 U.S. 46, 59-60 (1991). But *Wilmington Star* had specifically distinguished what "might be done in a criminal case," 205 U.S. at 78, and *Griffin* did not mention civil verdicts at all; it certainly did not purport to overrule *Wilmington Star*. *See Gillespie v. Sears, Roebuck & Co.*, 386 F.3d 21, 29-30 (1st Cir. 2004) (*Wilmington Star*, not *Griffin*, governs civil verdicts). Therefore, insufficient evidence as to ***any*** infringement theory—e.g., literal ***or*** DOE—as to ***any*** patent requires vacatur of the entire infringement verdict.[2]

And because the damages verdict awards an undifferentiated sum, *see infra* Part III.A, it is impossible to remit the damages award to correspond to a new trial's patent-specific infringement findings (if any). Consequently, if the

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[2] Although the Fifth Circuit recently called *Walther* law of the circuit and said decisions like *Muth* relied on "pre-*Griffin*" circuit precedent, it did not attempt to reconcile its reasoning with *Wilmington Star*. *Nester v. Textron, Inc.*, 888 F.3d 151, 159-160 (5th Cir. 2018). This Court's decision in *Northpoint* likewise did not address *Wilmington Star*. To the extent the Court reaches this issue, it should follow the on-point Supreme Court decision in *Wilmington Star*. *See State Oil Co. v. Khan*, 522 U.S. 3, 20 (1997) ("it is this Court's prerogative alone to overrule one of its precedents").

infringement verdict is vacated for any reason, the damages verdict must also be vacated fully. *Anderson v. Siemens Corp.*, 335 F.3d 466, 475-476 (5th Cir. 2003) ("given that the jury's award of damages fails to identify damages incurred as a result of Decedent's stroke separately and apart from those damages associated with Decedent's death," and given that the death-based liability verdict was reversed, "we conclude that there should be a retrial of all the issues raised, including damages"). Indeed, where an infringement verdict as to one patent is vacated and "the jury rendered a single verdict on damages [covering multiple patents] without breaking down the damages attributable to each patent, the normal rule would require a new trial as to damages," too. *Verizon Servs. Corp. v. Vonage Holdings Corp.*, 503 F.3d 1295, 1309-1310 (Fed. Cir. 2007); *see Commil USA, LLC v. Cisco Sys., Inc.*, 720 F.3d 1361, 1367 (Fed. Cir. 2013) (where undifferentiated damages verdict was based on both direct and induced infringement but Court "vacat[ed] the induced infringement verdict …, [Court] also vacate[d] the damages award"), *vacated on other grounds*, 575 U.S. 632 (2015).

## III. THE DAMAGES VERDICT SHOULD BE VACATED

### A. The Damages Verdict Was Not Based On An Actual Infringement Verdict

The damages verdict should be vacated because it was not supported by any jury finding of infringement. That disconnect was exacerbated by the court's

instruction that the retrial jury should determine a single damages amount for all five patents. The only solution is vacating the entire judgment and remanding for a new trial on infringement and damages.

Again, the infringement-verdict form asked the jury whether "Apple infringed **ANY** of the [nine] asserted claims" from the five asserted patents, and the jury simply answered "Yes." Appx101 (emphasis original). Consequently, it was "impossible" for the damages jury to know which patents—if any—the first jury found infringed. *Gasoline Prods. Co. v. Champlin Refining Co.*, 283 U.S. 494, 499 (1931). This left the damages jury a doubly impermissible task. ***First***, although royalty damages "must reflect the value attributable to the infringing features of the product, and no more," the damages jury could only speculate as to which features were found to infringe which patent. *Ericsson*, 773 F.3d at 1226 ("it is the value of what was taken that measures a reasonable royalty"); 35 U.S.C. § 284 (measure of damages must be "for the infringement"). ***Second***, "instructing a second jury to decide an issue that requires it to speculate about the basis of the first jury's verdict"—as the court did here—"is a prohibited reexamination" under the Seventh Amendment. *Searcy v. R.J. Reynolds Tobacco Co.*, 902 F.3d 1342, 1355 (11th Cir. 2018) (citing *Gasoline Prods.*, 283 U.S. at 499-500); *see* U.S. Const., Amend. VII ("no fact tried by a jury[] shall be otherwise reexamined in any court of the United States[] than according to the rules of the common law").

The court amplified the problem by repeatedly instructing the damages jury to determine a single damages amount for infringement of ***all five*** asserted patents. *See* Appx203; Appx3183 (task was to determine "compensation for the infringement of their five patents"); Appx211-212 (final instructions listing "five Patents-in-Suit," stating "it has been determined that [Apple's products] infringe the asserted patents," and stating jury's "job" is determine damages "to be awarded to Optis as compensation for the infringement of the Patents-in-Suit"). Correspondingly, the damages verdict form called for the jury to award a single amount as compensation "for the damages resulting from" undifferentiated "infringement," Appx217, and the jury in fact provided a single lump-sum award that was not attributed to any particular patent and exceeded the damages sought for any one patent. Appx215; Appx217-218; *see* Appx3543-3544. In telling the jury it should award damages for all five patents, these instructions went far beyond the court's own infringement judgment, which stated only (though still erroneously): "Apple has infringed ***one or more*** of the Asserted Claims." Appx134.

At this point, the only cure is retrial of both infringement and damages. A "partial new trial[] … may not properly be resorted to unless it clearly appears that the issue to be retried is so distinct and separable from the others that a trial of it alone may be had without injustice." *Gasoline Prods.*, 283 U.S. at 500; *see also,*

*e.g.*, *Encompass Office Sols., Inc. v. Louisiana Health Serv. & Indem. Co.*, 919 F.3d 266, 276 (5th Cir. 2019); *Commil*, 720 F.3d at 1371. This case is the opposite: because of the court's sweeping general-verdict forms, the issues of infringement and damages are inseparable. Retrial of damages alone could not cure the damages-verdict errors because a new damages jury still could not possibly know which patents were found infringed. And retrial of infringement alone could not cure the damages-verdict errors because it would be impossible to remit the undifferentiated damages award to match any new patent-specific infringement findings.

Retrial of both infringement and damages is thus mandated. In *Gasoline Products*, the initial jury made an undifferentiated damages award for two counterclaims. 283 U.S. at 496. The appellate court held "the measure of damages" erroneous and remanded for a new damages-only trial. *Id.* The Supreme Court, however, held that the Seventh Amendment required retrial of liability and damages together. Because the initial verdict only "established the existence of a contract and its breach," it would be "impossible" for a damages-only jury to ascertain from the initial verdict facts essential to "fix the amount of damages," e.g., the contract's terms and dates of formation and breach. *Id.* at 499-500. Consequently, "the question of damages … is so interwoven with that of liability that the former cannot be submitted to the jury independently of the latter

without confusion and uncertainty, which would amount to a denial of a fair trial." *Id.* at 500.

Apple repeatedly raised its concerns about the fatal mismatch between the infringement verdict and the damages charge, but the court rejected them without engaging with their substance. Appx3920; Appx229. Instead, the court merely said the damages instruction was "substantially equivalent to the instruction proposed by Apple," which said the jury was "to 'assume' that the 'patents-in-suit are valid and infringed.'" Appx229. The court severely misunderstood Apple's constant and unambiguous position.

***In the very proposed instructions*** the court cited, Apple pervasively raised its concerns about the disconnect between the infringement verdict and damages instructions: "Apple also preserves its objection that the jury verdict in the first trial did not specify which claim(s) or which patent(s) was/were found to be infringed, and thus contains no finding that any particular patent-in-suit was infringed, and certainly no finding that all five patents-in-suit have been infringed." Appx8742 n.6; *accord* Appx8745 n.13; Appx8749 n.17. Apple's request that the jury be instructed to "assume" infringement was made in the alternative, given that the court had overruled Apple's objection and was determined to hold a damages-only trial. *See* Appx8742 n.6; Appx8745 n.13; Appx8749 n.17; Appx8747 & n.14.

The broader course of the proceedings confirms Apple's preservation of its objection. Apple raised its concern before the damages retrial began, Appx8709-8710, on the proposed damages verdict form, Appx8733 n.3, on the first day of the retrial, Appx202-203; Appx3174-3175, and during the charge conference, Appx3919-3920. Apple was so clear and persistent that the court gave Apple a "running objection" on the issue. Appx202-203; Appx3174-3175.

In short, Apple's objection to the disconnect between the infringement verdict and the damages retrial was well-preserved and compelling, and requires a new trial as to both infringement and damages.

### B. The Court Erroneously Admitted Evidence Regarding The Apple-Qualcomm Agreements

Central to Optis's damages case were two agreements between Apple and Qualcomm from April 2019: a license agreement under which Apple would pay Qualcomm for a patent license, Appx3537-3539; Appx25899-26242, and a settlement agreement under which Apple paid to settle worldwide litigation. Appx3541; Appx26243-26365. Optis's damages expert, Mr. Kennedy, relied on these agreements in developing his damages proposal and repeatedly cited them at trial.

Over Apple's objections, Appx8418-8420; Appx8712-8713, the court admitted the agreements and Kennedy's corresponding testimony, Appx194-195; Appx202-203; Appx3174-3175; Appx72; Appx63-64; Appx238. That was

erroneous for two reasons. The testimony was irrelevant and unreliable because Kennedy admitted the agreements were not economically comparable to the hypothetical negotiation's determination of a FRAND license. And Kennedy's emphasis on the agreements' large noncomparable figures unfairly prejudiced Apple. These errors require a new trial.

**1. Noncomparability**

Expert testimony is admissible only if it is "relevant and reliable." *Uniloc USA, Inc. v. Microsoft Corp.*, 632 F.3d 1292, 1306 (Fed. Cir. 2011). Here, that means (among other things) "the patentee must sufficiently tie the expert testimony on damages to the facts of the case." *Id.* at 1315, 1317 (quotation marks and brackets omitted). Accordingly, existing license agreements "must be sufficiently comparable to the hypothetical license at issue." *Id.* at 1316; *see also Exmark Mfg. Co. v. Briggs & Stratton Power Prods. Grp., LLC*, 879 F.3d 1332, 1349 (Fed. Cir. 2018).

As Kennedy himself admitted, the Apple-Qualcomm agreements were not "sufficiently comparable to the Hypothetical License for use as a direct indication of a reasonable royalty rate." Appx7512(¶416). The record confirms that the agreements "radically differe[d] from the hypothetical agreement under consideration." *Lucent Techs., Inc. v. Gateway, Inc.*, 580 F.3d 1301, 1327-1328 (Fed. Cir. 2009). Kennedy improperly disregarded those differences. *Omega*

*Patents, LLC v. CalAmp Corp.*, 13 F.4th 1361, 1380 (Fed. Cir. 2021) (vacating judgment where "Omega failed to adequately account for substantial 'distinguishing facts' between the proffered licenses and a hypothetical negotiation").

Whereas this case requires a FRAND rate, the Apple-Qualcomm agreements arose from a context in which Qualcomm had considerable leverage over Apple. "Qualcomm wields its chip monopoly power to coerce OEMs to sign patent license agreements" by "threaten[ing] to withhold OEMs' chip supply until OEMs sign patent license agreements on Qualcomm's preferred terms." *FTC v. Qualcomm Inc.*, 411 F. Supp. 3d 658, 698 (N.D. Cal. 2019), *rev'd on other grounds*, 969 F.3d 974 (9th Cir. 2020). Qualcomm's "no license, no chips" policy undisputedly influenced Qualcomm's negotiation with Apple. Appx3775-3777; Appx25899. Kennedy admitted this. Appx7586-7587 (admitting Qualcomm "refused to provide Apple with new baseband chipsets without a license from Qualcomm" and Apple was dependent on Qualcomm for 5G chipsets); Appx3838; Appx3658; Appx3776.

Moreover, both agreements were formed to settle litigation and thus were "tainted by the coercive environment of … litigation." *LaserDynamics, Inc. v. Quanta Computer, Inc.*, 694 F.3d 51, 77 (Fed. Cir. 2012); *see Rude v. Westcott*, 130 U.S. 152, 164 (1889).

Additionally, the agreements had distinctive features. The settlement agreement, for its part, did not include a FRAND royalty for SEPs—the relevant inquiry here—but rather settled global litigation between Apple and Qualcomm, including [redacted]-plus matters spanning patent, antitrust, tortious interference, contract, and trade secret claims, as well as [redacted], for [redacted]. Appx25899; Appx26243-26245; Appx26248-26250; Appx26339-26359; Appx3656-3657; *see Apple Inc. v. Qualcomm Inc.*, No. 3:17-cv-00108, 2017 WL 3966944, at *3-4 (S.D. Cal. Sept. 7, 2017) (overview of claims). Kennedy focused his analysis on only ***one*** of those matters, assuming that the total settlement amount was motivated by a selection of 40 patents at issue in that matter. Dividing the ***total*** settlement payment by 40 to yield a per-patent average, Kennedy told the jury that his damages demand was in the "right ballpark." Appx3540-3542; Appx8811. That Kennedy attempted to cast the settlement agreement "as only a 'check' is of no moment." *Uniloc*, 632 F.3d at 1321. Kennedy still ignored the settlement's essential features that materially distinguished it from the hypothetical negotiation.

Regarding the license agreement, Kennedy did not explain how the royalty rate for approximately [redacted] patents, including [redacted], *see* Appx3584; Appx3659-3660; Appx3661; Appx3837-3838, provided a reasonable guide for a hypothetical negotiation involving five asserted patents. *Omega*, 13 F.4th at 1380-

1381 (licenses not comparable where expert failed to account for their much broader coverage). Indeed, this Court recently held Kennedy's similarly deficient testimony inadmissible. *See Apple Inc. v. Wi-LAN Inc.*, 25 F.4th 960, 971-974 (Fed. Cir. 2022) (proposed royalty rate relied on three license agreements that included broader set of patents, without explaining how they were comparable).

**2. Unfair prejudice**

Kennedy's Apple-Qualcomm testimony should also be excluded as unfairly prejudicial. *See* Fed. R. Evid. 403, 703.

Optis emphasized their high noncomparable dollar amounts, and Kennedy repeatedly recited those figures as a basis for arguing that Apple's "position" was "unreasonable" and the royalty rate should be "much higher." Appx3537-3541; *see* Appx3210. Optis plastered them on trial slides and gratuitously emphasized that the figure was "[redacted] … with a [redacted]." Appx3540; Appx8810-8811. Optis's use of these figures "'skew[ed] the damages horizon.'" *VirnetX, Inc. v. Cisco Sys., Inc.*, 767 F.3d 1308, 1327 (Fed. Cir. 2014) (quoting *Uniloc*, 632 F.3d at 1320); *see also Ericsson*, 773 F.3d at 1228 (large numbers from noncomparable agreements "skew[ed] unfairly the jury's ability to apportion the damages to account only for the value attributable to the infringing features"). This compounded the harm from Optis's improper references to Apple's profitability, as discussed next.

And Optis's reliance on these figures was unnecessary because Kennedy could have based his royalty analysis on the numerous Apple arm's-length licenses for LTE SEPs, along with an [redacted] license covering [redacted] ***of the*** [redacted] [redacted] ***patents***. Appx3816-3820; Appx3837; Appx3828-3832. But he refused to credit those benchmarks.

### C. The Court Erroneously Admitted Apple's General Profitability In The Cellular Industry

The district court erred in allowing Optis and Kennedy to repeatedly highlight Apple's general profitability in the cellular industry. That testimony was irrelevant and unreliable, contravened FRAND, and unfairly prejudiced Apple.

Kennedy testified that "Apple captures or garners sometimes 87 percent of all the profits in the cell phone industry." Appx3506. He told the jury, "Apple dominates smartphone industry" with "87 percent of the profits." Appx4000; Appx3289. And he said that Apple is "one of the most valuable [companies] in the world." Appx3509.

A "reasonable royalty analysis requires a court to … carefully tie proof of damages to the claimed invention's footprint in the market place." *VirnetX*, 767 F.3d at 1327; *see supra* p.58. Consequently, a "patentee may assess damages based on the entire market value of the accused product only where the patented feature creates the basis for customer demand or substantially creates the value of the component parts." *VirnetX*, 767 F.3d at 1326. But Optis made no attempt to

tie Apple's sales and profitability in the cellular industry generally to the accused features or the asserted patents.

Additionally, in this SEP case, the reasonable royalty rate must reflect FRAND, including that the rate be "non-discriminatory." *Ericsson*, 773 F.3d at 1230-1231. Optis's focus on Apple's leading industry position violated FRAND by suggesting that Apple should pay more simply because of its profitability.

Finally, Optis's focus on Apple's leading industry position unfairly prejudiced Apple. *See* Fed. R. Evid. 403, 703. "'[R]eliance on the entire market value of the accused products … cannot help but skew the damages horizon for the jury, regardless of the contribution of the patented component to this revenue.'" *VirnetX*, 767 F.3d at 1327 (quoting *Uniloc*, 632 F.3d at 1320). That happened here, with Optis's statements about Apple's 87% of the industry's profits and profitability relative to [redacted]. Especially combined with Optis's references to Apple's [redacted] settlement with Qualcomm, the jury easily could have determined that Apple's mobile devices earn [redacted] in profits. *See supra* p.61.

But over Apple's objections, Appx3506-3510; Appx3936, the court concluded that this testimony was admissible to rebut Apple's reliance on evidence regarding [redacted], Appx195-196; Appx3510; *see* Appx245-246. That was erroneous. Apple's expert cited [redacted] royalty rates for [redacted] of the [redacted] patents as a measure of the reasonable royalty rate, given that both

companies are similarly situated in the cellular industry. *See* Appx3828-3832. Optis ignored that evidence, *see* Appx3426; Appx3443-3444; Appx3486; Appx3546-3548; Appx3551-3552; Appx3557; Appx3568-3569, instead, as discussed, emphasizing Apple's profitability, contrary to FRAND.

### D. The Court Erroneously Admitted Evidence From The Parties' Confidential Settlement Negotiations

Optis repeatedly disclosed to the jury details about the parties' confidential negotiations regarding licensing the asserted patents. The court erred in admitting that evidence, unfairly prejudicing Apple.

Optis's opening statement asserted: "[B]etween 2017 and February of 2019, PanOptis repeatedly, repeatedly, repeatedly asked Apple to take a license for the LTE technology that PanOptis held. Apple declined. … Apple said, we want litigation." Appx3208-3209. Optis went further, eliciting testimony that Optis offered a license for "[a]pproximately $500 million" and that Apple "informed [Optis] that they did not want to take a license." Appx3246-3250.

Those statements were inadmissible for three reasons. First, Federal Rule of Evidence 408 barred them as "statement[s] made during compromise negotiations about the claim." Fed. R. Evid. 408; *see* Appx8711. Second, the parties' confidentiality agreement barred them. Appx35001-35002(¶¶2, 4); Appx8711. Third, they were irrelevant to determining a FRAND royalty based on a 2012 hypothetical negotiation—the jury's sole proper task—in two ways. *See*

Appx8711. One is that the offer was made at least five years after the hypothetical negotiation, which occurs "on the eve of infringement" because the subsequent threat of infringement litigation "skew[s]" the "damages analysis." *LaserDynamics*, 694 F.3d at 75-76. The other is that a patentee's own offer is inherently self-serving and not objective evidence of a reasonable royalty. *Whitserve, LLC v. Computer Packages, Inc.*, 694 F.3d 10, 29-30 (Fed. Cir. 2012) ("patentees could artificially inflate the royalty rate by making outrageous offers").

This evidence unfairly prejudiced Apple by painting it as an "unwilling" licensee deserving punishment through an inflated damages award, whereas the jury's proper task was to assume a "willing" licensee. *LaserDynamics*, 694 F.3d at 75; *see* Appx8711-8712. The court, however, indicated that Apple had "waive[d]" its objection to the use of confidential settlement statements because it "chose to introduce [such] evidence …, beginning with a slide in Apple's opening demonstratives." Appx252. But the general rule that a party waives its admissibility objection "if [it] later introduces evidence of the same or similar import itself," *id.*, does not apply here because Apple did so only in response to Optis's introduction of such evidence after the court had conclusively overruled Apple's objection.

Before trial began, the court denied Apple's motion *in limine* seeking to exclude these settlement statements. Appx8417-8418; Appx149-150; Appx194-

195. Then, on the eve of trial, Optis sought to bar Apple from introducing settlement evidence, although Optis itself intended to use settlement evidence. Apple responded that Optis cannot have it both ways: "With the Court having overruled Apple's objection to the admission of negotiation materials, ***all*** those materials should come in," lest Optis "create a grossly distorted presentation of the facts to the jury." Appx8721-8722. On the first day of trial, Apple reiterated both its objection to settlement evidence and its conditional fallback position that, given the court's ruling and Optis's reliance on settlement evidence, Apple must be able to do the same: "[W]hile Apple believes that the right answer is for ***neither*** party to offer ***any*** evidence of their licensing negotiations, if Plaintiffs are allowed to tell the jury any part of the negotiation history … (as Plaintiffs' opening demonstratives indicate they intend to do), then Apple should be able to offer contextualizing evidence regarding 'the totality of the conduct.'" Appx8899 (emphasis original); *see* Appx251-252; Appx3174-3177. It was Optis that first revealed the $500 million settlement offer in its opening, long before the jury saw any of Apple's demonstratives. Appx3208.

Under these circumstances, Apple had the right to respond to Optis on this topic. *See, e.g.*, *Judd v. Rodman*, 105 F.3d 1339, 1342 (11th Cir. 1997) ("Judd presented evidence of her prior sexual history on direct examination only after the court overruled her motion in limine to exclude [it]. … [T]his constituted valid

trial strategy and, as a result, … Judd did not waive her objection."); *see also Reyes v. Missouri Pac. R.R. Co.*, 589 F.2d 791, 793 & n.2 (5th Cir. 1979).

On the merits, the court also erred. Again, it denied Apple's exclusion motion, reasoning that "the jury is entitled to view the totality of the conduct," Appx150; Appx194-195, but any such "right" is limited by Rule 408, the parties' confidentiality agreement, and the evidence's irrelevance and prejudicial effect—none of which the court addressed. Later, the court said the prejudice "was obviated by [its] instruction to the jury to assume that both parties were willing to enter into an agreement, as well as [its] instruction that their damages award should not 'punish' the alleged infringer." Appx251. Those generic instructions, three days after Optis introduced the evidence, *see* Appx3946-3947, were too little too late.

## CONCLUSION

The district court's judgment should be reversed or vacated and remanded.

Respectfully submitted,

/s/ Mark C. Fleming

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April 28, 2025

# ADDENDUM

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**Page(s)**

## ORDERS, VERDICT, AND JUDGMENT

**PATENTS-IN-SUIT**



**CONFIDENTIAL MATERIAL OMITTED**

The material omitted from Addendum page Appx63 contains confidential information regarding the settlement agreement between Apple and Qualcomm; and the material omitted from pages Appx231-232, Appx235-240, Appx243, Appx248-252, Appx254-255, Appx258, and Appx262-264 contains confidential information regarding license agreements and licensing negotiations, and confidential sealed testimony regarding the same.

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | |
|---|---|
| **OPTIS WIRELESS TECHNOLOGY, LLC ET AL.,**<br>***Plaintiffs,***<br><br>**v.**<br><br>**APPLE INC.,**<br>***Defendant.*** | **Case No. 2:19-cv-00066-JRG** |

**CLAIM CONSTRUCTION MEMORANDUM OPINION AND ORDER**

Before the Court is the opening claim construction brief of Optis Wireless Technology, LLC, Optis Cellular Technology, LLC, and PanOptis Patent Management, LLC (collectively, "Plaintiffs") (Dkt. No. 82),[1] the response of Apple Inc. ("Defendant") (Dkt. No. 86), and Plaintiffs' reply (Dkt. No. 92). The Court held a hearing on the issues of claim construction and claim definiteness on February 25, 2020. Having considered the arguments and evidence presented by the parties at the hearing and in their briefing, the Court issues this Order.

[1] Citations to the parties' filings are to the filing's number in the docket (Dkt. No.) and pin cites are to the page numbers assigned through ECF.

## Table of Contents

## I. BACKGROUND

Plaintiffs allege infringement of seven U.S. Patents: No. 8,005,154 (the "'154 Patent"), No. 8,019,332 (the "'332 Patent"), No. 8,102,833 (the "'833 Patent"), No. 8,385,284 (the "'284 Patent"), No. 8,411,557 (the "'557 Patent"), No. 8,989,290 (the "'290 Patent"),[2] and No. 9,001,774 (the "'774 Patent") (collectively, the "Asserted Patents").

## II. LEGAL PRINCIPLES

### A. Claim Construction

"It is a 'bedrock principle' of patent law that 'the claims of a patent define the invention to which the patentee is entitled the right to exclude.'" *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc) (quoting *Innova/Pure Water Inc. v. Safari Water Filtration Sys., Inc.*, 381 F.3d 1111, 1115 (Fed. Cir. 2004)). To determine the meaning of the claims, courts start by considering the intrinsic evidence. *Id.* at 1313; *C.R. Bard, Inc. v. U.S. Surgical Corp.*, 388 F.3d 858, 861 (Fed. Cir. 2004); *Bell Atl. Network Servs., Inc. v. Covad Commc'ns Group, Inc.*, 262 F.3d 1258, 1267 (Fed. Cir. 2001). The intrinsic evidence includes the claims themselves, the specification, and the prosecution history. *Phillips*, 415 F.3d at 1314; *C.R. Bard, Inc.*, 388 F.3d at 861. The general rule—subject to certain specific exceptions discussed *infra*—is that each claim term is construed according to its ordinary and accustomed meaning as understood by one of ordinary skill in the art at the time of the invention in the context of the patent. *Phillips*, 415 F.3d at 1312–13; *Alloc, Inc. v. Int'l Trade Comm'n*, 342 F.3d 1361, 1368 (Fed. Cir. 2003); *Azure Networks, LLC v. CSR PLC*, 771 F.3d 1336, 1347 (Fed. Cir. 2014) ("There is a heavy presumption that claim terms carry their accustomed meaning in the relevant community at the relevant time.") (vacated on other grounds).

[2] The parties did not submit any dispute regarding the scope of the '290 Patent. Since the hearing, the '290 Patent was dismissed from the case. (Dkt. No. 105.)

"The claim construction inquiry . . . begins and ends in all cases with the actual words of the claim." *Renishaw PLC v. Marposs Societa' per Azioni*, 158 F.3d 1243, 1248 (Fed. Cir. 1998). "[I]n all aspects of claim construction, 'the name of the game is the claim.'" *Apple Inc. v. Motorola, Inc.*, 757 F.3d 1286, 1298 (Fed. Cir. 2014) (quoting *In re Hiniker Co.*, 150 F.3d 1362, 1369 (Fed. Cir. 1998)). First, a term's context in the asserted claim can be instructive. *Phillips*, 415 F.3d at 1314. Other asserted or unasserted claims can also aid in determining the claim's meaning, because claim terms are typically used consistently throughout the patent. *Id.* Differences among the claim terms can also assist in understanding a term's meaning. *Id*. For example, when a dependent claim adds a limitation to an independent claim, it is presumed that the independent claim does not include the limitation. *Id*. at 1314–15.

"[C]laims 'must be read in view of the specification, of which they are a part.'" *Id*. at 1315 (quoting *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 979 (Fed. Cir. 1995) (en banc)). "[T]he specification 'is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term.'" *Phillips*, 415 F.3d at 1315 (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)); *Teleflex, Inc. v. Ficosa N. Am. Corp.*, 299 F.3d 1313, 1325 (Fed. Cir. 2002). But, "'[a]lthough the specification may aid the court in interpreting the meaning of disputed claim language, particular embodiments and examples appearing in the specification will not generally be read into the claims.'" *Comark Commc'ns, Inc. v. Harris Corp.*, 156 F.3d 1182, 1187 (Fed. Cir. 1998) (quoting *Constant v. Advanced Micro-Devices, Inc.*, 848 F.2d 1560, 1571 (Fed. Cir. 1988)); *see also Phillips*, 415 F.3d at 1323. "[I]t is improper to read limitations from a preferred embodiment described in the specification—even if it is the only embodiment—into the claims absent a clear

indication in the intrinsic record that the patentee intended the claims to be so limited." *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 913 (Fed. Cir. 2004).

The prosecution history is another tool to supply the proper context for claim construction because, like the specification, the prosecution history provides evidence of how the U.S. Patent and Trademark Office ("PTO") and the inventor understood the patent. *Phillips*, 415 F.3d at 1317. However, "because the prosecution history represents an ongoing negotiation between the PTO and the applicant, rather than the final product of that negotiation, it often lacks the clarity of the specification and thus is less useful for claim construction purposes." *Id.* at 1318; *see also Athletic Alternatives, Inc. v. Prince Mfg.*, 73 F.3d 1573, 1580 (Fed. Cir. 1996) (ambiguous prosecution history may be "unhelpful as an interpretive resource").

Although extrinsic evidence can also be useful, it is "'less significant than the intrinsic record in determining the legally operative meaning of claim language.'" *Phillips*, 415 F.3d at 1317 (quoting *C.R. Bard, Inc.*, 388 F.3d at 862). Technical dictionaries and treatises may help a court understand the underlying technology and the manner in which one skilled in the art might use claim terms, but technical dictionaries and treatises may provide definitions that are too broad or may not be indicative of how the term is used in the patent. *Id*. at 1318. Similarly, expert testimony may aid a court in understanding the underlying technology and determining the particular meaning of a term in the pertinent field, but an expert's conclusory, unsupported assertions as to a term's definition are not helpful to a court. *Id*. Extrinsic evidence is "less reliable than the patent and its prosecution history in determining how to read claim terms." *Id*. The Supreme Court has explained the role of extrinsic evidence in claim construction:

> In some cases, however, the district court will need to look beyond the patent's intrinsic evidence and to consult extrinsic evidence in order to understand, for example, the background science or the meaning of a term in the relevant art during the relevant time period. *See, e.g., Seymour v. Osborne*, 11 Wall. 516, 546 (1871)

> (a patent may be "so interspersed with technical terms and terms of art that the testimony of scientific witnesses is indispensable to a correct understanding of its meaning"). In cases where those subsidiary facts are in dispute, courts will need to make subsidiary factual findings about that extrinsic evidence. These are the "evidentiary underpinnings" of claim construction that we discussed in *Markman*, and this subsidiary factfinding must be reviewed for clear error on appeal.

*Teva Pharm. USA, Inc. v. Sandoz, Inc.*, 135 S. Ct. 831, 841 (2015).

### B. Departing from the Ordinary Meaning of a Claim Term

There are "only two exceptions to [the] general rule" that claim terms are construed according to their plain and ordinary meaning: "1) when a patentee sets out a definition and acts as his own lexicographer, or 2) when the patentee disavows the full scope of the claim term either in the specification or during prosecution."[3] *Golden Bridge Tech., Inc. v. Apple Inc.*, 758 F.3d 1362, 1365 (Fed. Cir. 2014) (quoting *Thorner v. Sony Computer Entm't Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012)); *see also GE Lighting Solutions, LLC v. AgiLight, Inc.*, 750 F.3d 1304, 1309 (Fed. Cir. 2014) ("[T]he specification and prosecution history only compel departure from the plain meaning in two instances: lexicography and disavowal."). The standards for finding lexicography or disavowal are "exacting." *GE Lighting Solutions*, 750 F.3d at 1309.

To act as his own lexicographer, the patentee must "clearly set forth a definition of the disputed claim term," and "clearly express an intent to define the term." *Id.* (quoting *Thorner*, 669 F.3d at 1365); *see also Renishaw*, 158 F.3d at 1249. The patentee's lexicography must appear "with reasonable clarity, deliberateness, and precision." *Renishaw*, 158 F.3d at 1249.

To disavow or disclaim the full scope of a claim term, the patentee's statements in the specification or prosecution history must amount to a "clear and unmistakable" surrender. *Cordis*

---

[3] Some cases have characterized other principles of claim construction as "exceptions" to the general rule, such as the statutory requirement that a means-plus-function term is construed to cover the corresponding structure disclosed in the specification. *See, e.g., CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d 1359, 1367 (Fed. Cir. 2002).

*Corp. v. Boston Sci. Corp.*, 561 F.3d 1319, 1329 (Fed. Cir. 2009); *see also Thorner*, 669 F.3d at 1366 ("The patentee may demonstrate intent to deviate from the ordinary and accustomed meaning of a claim term by including in the specification expressions of manifest exclusion or restriction, representing a clear disavowal of claim scope."). "Where an applicant's statements are amenable to multiple reasonable interpretations, they cannot be deemed clear and unmistakable." *3M Innovative Props. Co. v. Tredegar Corp.*, 725 F.3d 1315, 1326 (Fed. Cir. 2013).

### C. Functional Claiming and 35 U.S.C. § 112, ¶ 6 (pre-AIA) / § 112(f) (AIA)

A patent claim may be expressed using functional language. *See* 35 U.S.C. § 112, ¶ 6; *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1347–49 & n.3 (Fed. Cir. 2015) (en banc in relevant portion). Section 112, Paragraph 6, provides that a structure may be claimed as a "means . . . for performing a specified function" and that an act may be claimed as a "step for performing a specified function." *Masco Corp. v. United States*, 303 F.3d 1316, 1326 (Fed. Cir. 2002).

But § 112, ¶ 6 does not apply to all functional claim language. There is a rebuttable presumption that § 112, ¶ 6 applies when the claim language includes "means" or "step for" terms, and that it does not apply in the absence of those terms. *Masco*, 303 F.3d at 1326; *Williamson*, 792 F.3d at 1348. The presumption stands or falls according to whether one of ordinary skill in the art would understand the claim with the functional language, in the context of the entire specification, to denote sufficiently definite structure or acts for performing the function. *See Media Rights Techs., Inc. v. Capital One Fin. Corp.*, 800 F.3d 1366, 1372 (Fed. Cir. 2015) (§ 112, ¶ 6 does not apply when "the claim language, read in light of the specification, recites sufficiently definite structure" (quotation marks omitted) (citing *Williamson*, 792 F.3d at 1349; *Robert Bosch, LLC v. Snap-On Inc.*, 769 F.3d 1094, 1099 (Fed. Cir. 2014))); *Williamson*, 792 F.3d at 1349 (§ 112, ¶ 6 does not apply when "the words of the claim are understood by persons of ordinary skill in the art

to have sufficiently definite meaning as the name for structure"); *Masco*, 303 F.3d at 1326 (§ 112, ¶ 6 does not apply when the claim includes an "act" corresponding to "how the function is performed"); *Personalized Media Communications, L.L.C. v. International Trade Commission*, 161 F.3d 696, 704 (Fed. Cir. 1998) (§ 112, ¶ 6 does not apply when the claim includes "sufficient structure, material, or acts within the claim itself to perform entirely the recited function … even if the claim uses the term 'means.'" (quotation marks and citation omitted)).

When it applies, § 112, ¶ 6 limits the scope of the functional term "to only the structure, materials, or acts described in the specification as corresponding to the claimed function and equivalents thereof." *Williamson*, 792 F.3d at 1347. Construing a means-plus-function limitation involves multiple steps. "The first step … is a determination of the function of the means-plus-function limitation." *Medtronic, Inc. v. Advanced Cardiovascular Sys., Inc.*, 248 F.3d 1303, 1311 (Fed. Cir. 2001). "[T]he next step is to determine the corresponding structure disclosed in the specification and equivalents thereof." *Id.* A "structure disclosed in the specification is 'corresponding' structure only if the specification or prosecution history clearly links or associates that structure to the function recited in the claim." *Id.* The focus of the "corresponding structure" inquiry is not merely whether a structure is capable of performing the recited function, but rather whether the corresponding structure is "clearly linked or associated with the [recited] function." *Id.* The corresponding structure "must include all structure that actually performs the recited function." *Default Proof Credit Card Sys. v. Home Depot U.S.A., Inc.*, 412 F.3d 1291, 1298 (Fed. Cir. 2005). However, § 112 does not permit "incorporation of structure from the written description beyond that necessary to perform the claimed function." *Micro Chem., Inc. v. Great Plains Chem. Co.*, 194 F.3d 1250, 1258 (Fed. Cir. 1999).

For § 112, ¶ 6 limitations implemented by a programmed general purpose computer or microprocessor, the corresponding structure described in the patent specification must include an algorithm for performing the function. *WMS Gaming Inc. v. Int'l Game Tech.*, 184 F.3d 1339, 1349 (Fed. Cir. 1999). The corresponding structure is not a general purpose computer but rather the special purpose computer programmed to perform the disclosed algorithm. *Aristocrat Techs. Austl. Pty Ltd. v. Int'l Game Tech.*, 521 F.3d 1328, 1333 (Fed. Cir. 2008).

**D. Definiteness Under 35 U.S.C. § 112, ¶ 2 (pre-AIA) / § 112(b) (AIA)**

Patent claims must particularly point out and distinctly claim the subject matter regarded as the invention. 35 U.S.C. § 112, ¶ 2. A claim, when viewed in light of the intrinsic evidence, must "inform those skilled in the art about the scope of the invention with reasonable certainty." *Nautilus Inc. v. Biosig Instruments, Inc.*, 572 U.S. 898, 910 (2014). If it does not, the claim fails § 112, ¶ 2 and is therefore invalid as indefinite. *Id.* at 901. Whether a claim is indefinite is determined from the perspective of one of ordinary skill in the art as of the time the application for the patent was filed. *Id.* at 911. As it is a challenge to the validity of a patent, the failure of any claim in suit to comply with § 112 must be shown by clear and convincing evidence. *BASF Corp. v. Johnson Matthey Inc.*, 875 F.3d 1360, 1365 (Fed. Cir. 2017). "[I]ndefiniteness is a question of law and in effect part of claim construction." *ePlus, Inc. v. Lawson Software, Inc.*, 700 F.3d 509, 517 (Fed. Cir. 2012).

When a term of degree is used in a claim, "the court must determine whether the patent provides some standard for measuring that degree." *Biosig Instruments, Inc. v. Nautilus, Inc.*, 783 F.3d 1374, 1378 (Fed. Cir. 2015) (quotation marks omitted). Likewise, when a subjective term is used in a claim, "the court must determine whether the patent's specification supplies some standard for measuring the scope of the [term]." *Datamize, LLC v. Plumtree Software, Inc.*, 417

F.3d 1342, 1351 (Fed. Cir. 2005). The standard "must provide objective boundaries for those of skill in the art." *Interval Licensing LLC v. AOL, Inc.*, 766 F.3d 1364, 1371 (Fed. Cir. 2014).

In the context of a claim governed by 35 U.S.C. § 112, ¶ 6, the claim is invalid as indefinite if the claim fails to disclose adequate corresponding structure to perform the claimed function. *Williamson*, 792 F.3d at 1351–52. The disclosure is inadequate when one of ordinary skill in the art "would be unable to recognize the structure in the specification and associate it with the corresponding function in the claim." *Id.* at 1352.

## III. AGREED CONSTRUCTIONS

The parties have agreed to the following constructions set forth in their P.R. 4-3 Joint Claim Construction and Prehearing Chart.[4] (Dkt. No. 76.)

| Term | Agreed Construction |
|---|---|
| "serially multiplexing first control signals and data signals, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals"<br>• ’833 Patent Claims 1, 8 | first control signals and data signals are mapped with a sequence in which one is directly after the other, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals |
| "mapping the multiplexed signals to"<br>• ’833 Patent Claim 1, 8 | after placing the first control signals and the data signals [in step (a)], mapping the multiplexed signals to |
| "mapping ACK/NACK control signals to"<br>• ’833 Patent Claim 1, 8 | after mapping the multiplexed signals [in step (b)], mapping ACK/NACK control signals to |
| "transport format"<br>• ’284 Patent Claim 1, 14[5] | transport format, transport block size, payload size, or modulation and coding scheme |
| "based on a received uplink signal"<br>• ’774 Patent Claim 6 | no construction necessary |

[4] The parties did not provide these agreements in their P.R. 4-5(d) Joint Claim Construction Chart (Dkt. No. 95.)

[5] Only the highest-level claim in each dependency chain is listed.

Having reviewed the intrinsic and extrinsic evidence of record, the Court hereby adopts the parties' agreed constructions.

## IV. CONSTRUCTION OF DISPUTED TERMS

### A. U.S. Patent No. 8,005,154

The '154 Patent is entitled Method and Apparatus for Transmitting and Receiving Shared Control Channel Message in a Wireless Communication System Using Orthogonal Frequency Division Multiple Access. The application leading to the '154 Patent was filed on December 26, 2007 and the patent states a priority claim to a foreign application filed on December 22, 2006.

In general, the patent is directed to technology for "configuring and transmitting/receiving a message of a Forward Shared Control Channel (F-SCCH) to support various antenna technologies for forward data transmission in a wireless communication system using OFDMA." '154 Patent at 7:58–62. A "shared control channel … includes control information necessary for demodulation of the transmission data" that is transmitted together with the shared control channel. *Id*. at 5:9–13. In an embodiment of the invention, the shared control channel includes a TD-FLAM field to "identify Transmit Diversity (TD) technologies agreed upon between a base station and a terminal to determine which precoding is used for data transmission in an OFDMA wireless communication system." *Id*. 6:29–33; *see also, id.* at 8:8–67.

With reference to Figure 6, reproduced and annotated by the Court below, the patent describes an exemplary "process in which to demodulate data transmitted over the forward link, a terminal receives a shared control channel, analyzes its message, and demodulates a data channel depending on the analysis result." *Id*. at 11:7–10. "In step 602, the terminal receives a shared control channel from the base station, and demodulates it to acquire a message. In step 603 [(green)], the terminal determines whether the base station uses the common pilot or uses the dedicated pilot at the corresponding time." *Id*. at 11:15–20. In step 604 (green), the terminal determines whether

precoding feedback (BFCH) is enabled. *Id.* at 11:20–23. The patent elsewhere explains that "[t]he rule for determining which feedback channel the base station will enable and which feedback channel the base station will disable is commonly agreed upon between the base station and the terminal by Layer-3 signaling." *Id.* at 9:30–33. Based on pilot and feedback type, the message type is then determined (605, 608, and 611, yellow). *Id.* at 11:20–27, 11:38–41, 11:52–54. The data

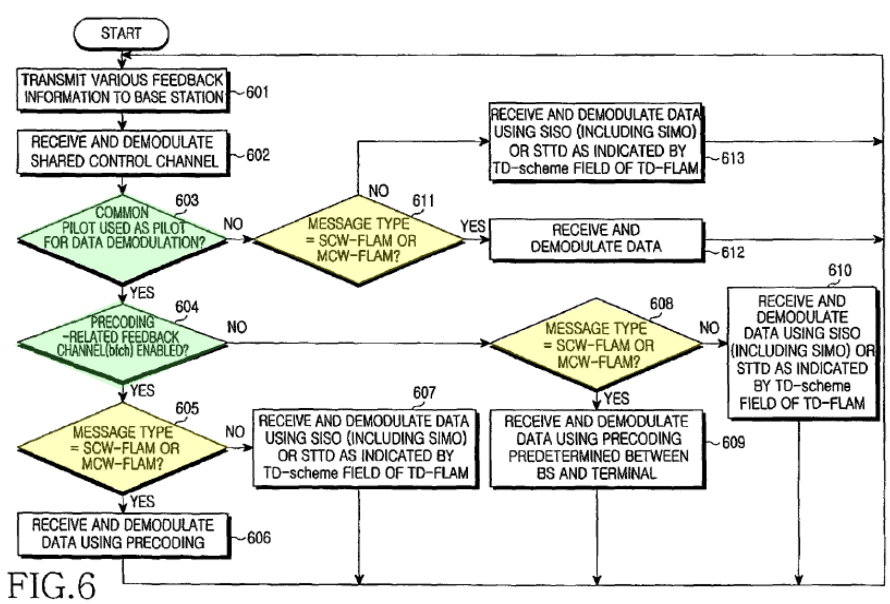

FIG.6

channel is received and demodulated based on the message type and TD-FLAM control information (606, 607, 609, 610, 612, 613).

The patent also describes an exemplary receiver with reference to Figure 8, reproduced and annotated by the Court below: "the receiver includes a demodulation and channel decoding unit 802, a control information extractor 803, a controller 804, a reception processor 805, a reception combiner 806, and a demodulation, channel decoding & interference cancellation unit 807." *Id.* at 12:35–39. Operation of the receiver is described as follows:

> A control channel reception unit composed of the demodulation and channel decoding unit 802 and the ***control information extractor 803*** extracts control information ***through a demodulation and channel decoding process on the signal received over a specific control channel***. The ***extracted control information is input to the controller 804***. The controller 804 controls a data channel reception

unit composed of the reception processor 805, the reception combiner 806 and the demodulation, channel decoding & interference cancellation unit 807 using the method described in FIG. 6.

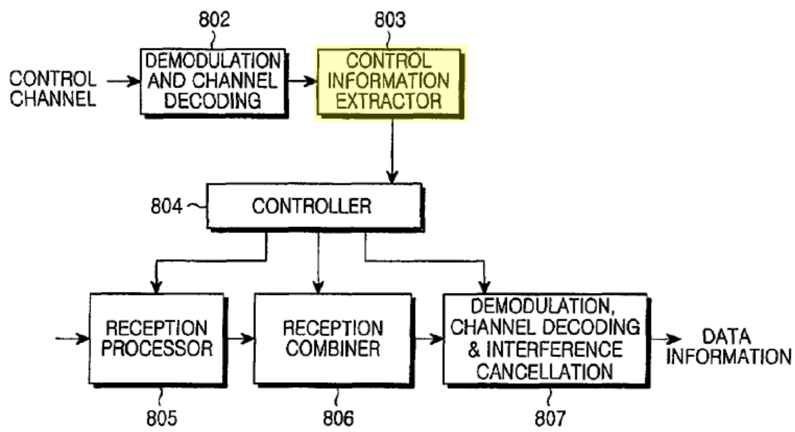


FIG.8

*Id*. at 12:40–49 (emphasis added).

The abstract of the ’154 Patent provides:

> A method and apparatus for transmitting/receiving a shared control channel message in an Orthogonal Frequency Division Multiple Access (OFDMA) wireless communication system are provided. The message transmission apparatus receives feedback information from a terminal; determines whether to transmit data by applying preceding; and transmits, in the shared control channel message, control information whose message type is differently set according to the application of the preceding. The message reception apparatus receives the shared control channel message from a base station; determines a message type of the shared control channel message; and if the message type is a Transmit Diversity (TD)-Forward Link Assignment Message (FLAM), demodulates data by at least one of Single Input Single Output (SISO) and Spatial Time Transmit Diversity (STTD) as indicated by the TD-FLAM.

Claim 37, an exemplary asserted claim from the ’154 Patent, is reproduced below with the term in dispute emphasized:

> **37**. An apparatus for receiving downlink shared channel in an Orthogonal Frequency Division Multiple Access (OFDMA) wireless communication system, the apparatus comprising:
>
> a reception unit for receiving downlink control channel comprising transmission scheme information for downlink shared channel data and downlink shared channel data from a base station;

a ***control information extractor for configuring transmission information for the downlink control channel via higher layer signaling***;
a demodulator for demodulating the downlink shared channel data; and
a controller for controlling the reception unit to receive the downlink control channel with a format corresponding to the transmission information and the demodulator to demodulate the downlink shared channel data according to the transmission scheme information included in the format,
wherein the transmission scheme information indicates that a Transmit Diversity or Open-Loop Spatial Multiplexing is used for transmitting the downlink shared channel data.

### A-1. "control information extractor for configuring transmission information for the downlink control channel via higher layer signaling"

| Disputed Term[6] | Plaintiffs' Proposed Construction | Defendant's Proposed Construction |
|---|---|---|
| "control information extractor for configuring transmission information for the downlink control channel via higher layer signaling"<br><br>• '154 Patent Claim 37 | no construction necessary: not 35 U.S.C. § 112, ¶ 6, not indefinite<br><br>alternatively (if § 112, ¶ 6),<br>• **function**: configuring transmission information for the downlink control channel via higher layer signaling<br>• **structure**: hardware programmed, or hardware with software programmed, to extract transmission information for the downlink control channel; for example, as shown and described in Figures 5, 6, and 8 and at 9:1-33, 11:12-65 and 12:33-58, and equivalents thereof | 35 U.S.C. § 112, ¶ 6, indefinite<br><br>• **function**: configuring transmission information for the downlink control channel via higher layer signaling<br>• **structure**: indefinite |

**<u>The Parties' Positions</u>**

Plaintiffs submit: The "control information extractor" term is not governed by 35 U.S.C. § 112, ¶ 6 for two reasons. First, the term "control information extractor" is a term of art for specific structure. Second, the claim provides the structure of this term by providing the

[6] For all disputed-term charts in this order, the claims in which the term is found are listed with the term but: (1) only the highest-level claim in each dependency chain is listed, and (2) only asserted claims identified in the parties' P.R. 4-5(d) Joint Claim Construction Chart (Dkt. No. 95) are listed.

"objectives and operations" of the extractor. Thus, the presumption against applying § 112, ¶ 6 is not overcome. Even if § 112, ¶ 6 applies to this term, the '154 Patent satisfies that statute's disclosure requirements (citing '154 Patent Figs.5, 8; 9:30–33, 9:63–10 :15, 11:30–36, 12:35–45, 12:64–67). (Dkt. No. 82 at 9–13.)

In addition to the claims themselves, Plaintiffs cite the following intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '154 Patent Figs.5, 8; 9:30–33, 9:63–10:15, 11:30–36, 12:35–45, 12:64–67. **Extrinsic evidence**: Mahon Decl.[7] ¶¶ 93–113 (Plaintiffs' Ex. 7, Dkt. No. 82-7); Akbar Rahbar, *Quality of Service in Optical Packet Switched Networks* 310–11 (2015) (Plaintiffs' Ex. 8, Dkt. No. 82-8 at 20–21); *Microsoft Computer Dictionary* at 203 (5th ed. 2002), "extract" (Plaintiffs' Ex. 9, Dkt. No. 82-9 at 4).

Defendant responds: The "control information extractor" term is governed by § 112, ¶ 6 and is indefinite because: (1) the extractor is defined by its function rather than being a name for definite structure, (2) the claim itself does not provide sufficient structure for performing the recited function, and (3) the '154 Patent does not disclose structure for performing the recited function, which requires "configuring … via higher layer signaling" at the mobile station rather than extracting control information. First, the *Rahbar* publication that Plaintiffs' present as evidence that "control information extractor" is a term of art denoting definite structure does not establish such. Rather, *Rahbar* is addressed to different art (optical-fiber networks instead of wireless communications), postdates the '154 Patent's filing date by eight years, uses the term "control information extractor unit" to denote a functional black box rather than any structure, and describes a different function than is provided in the claim. Second, the claim-recited function alone does not denote any definite structure. Finally, the "control information extractor" described

[7] Dr. Mark Mahon's Declaration in Support of Plaintiffs' Claim Construction Positions.

in the patent is merely a functional black box, not structure, and it is not clearly linked with the claimed function. In fact, there is no structure described in the patent that is linked with "configuring transmission information for the downlink control channel via higher layer signaling" at the mobile station. (Dkt. No. 86 at 7–14.)

In addition to the claims themselves, Defendant cites the following intrinsic and extrinsic evidence to support its position: **Intrinsic evidence**: '154 Patent Fig.8, 9:30–33, 12:1–52, 12:54–55. **Extrinsic evidence**: Beuhrer Decl.[8] ¶¶ 40–41, 45–48, 50–57, 60 (Defendant's Ex. 2, Dkt. No. 86-3); *Rahbar* at 310 (Dkt. No. 82-8 at 20).

Plaintiffs reply: While the '154 Patent may describe the "configuring" function in the context of a base station, the description sufficiently informs the claimed configuring for the mobile station. For example, Figure 6 depicts a flow for configuring the mobile station based on control information received by the mobile station. (Dkt. No. 92 at 6–8.)

Plaintiffs cite further intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '154 Patent Fig.6. **Extrinsic evidence**: Mahon Decl. ¶ 47.

**Analysis**

There are two issues in dispute. First, whether the "control information extractor" term should be governed by 35 U.S.C. § 112, ¶ 6. Second, if the term is governed by § 112, ¶ 6, whether the '154 Patent satisfies the disclosure requirements of the statute. The Court determines that this term is not governed by § 112, ¶ 6 and therefore does not address the second issue.

Defendant has not overcome the presumption against applying § 112, ¶ 6. The Court begins with the presumption that § 112, ¶ 6 does not apply because the term does not include the "means"

---

[8] Declaration of Dr. R. Michael Buehrer in Support of Defendant Apple Inc.'s Claim Construction Brief

language traditionally used to signal application of the statute. *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1347–49 & n.3 (Fed. Cir. 2015) (en banc in relevant portion). This "presumption can be overcome and § 112, para. 6 will apply if the challenger demonstrates that the claim term fails to recite sufficiently definite structure or else recites function without reciting sufficient structure for performing that function." *Id.* at 1349 (quotation marks omitted). "[T]he mere fact that the disputed limitations incorporate functional language does not automatically convert the words into means for performing such functions." *Zeroclick, LLC v. Apple Inc.*, 891 F.3d 1003, 1008 (Fed. Cir. 2018). "The question whether [a term] invokes section 112, paragraph 6, depends on whether persons skilled in the art would understand the claim language to refer to structure, assessed in light of the presumption that flows from the drafter's choice not to employ the word 'means.'" *Samsung Elecs. Am., Inc. v. Prisua Eng'g Corp.*, 948 F.3d 1342, 1354 (Fed. Cir. 2020). Here, Defendant has not overcome the presumption against § 112, ¶ 6.

"Control information extractor" connotes structure; namely, software/hardware in a communication device that includes functionality for configuring transmission information for the downlink control channel. Claim 1 provides sufficient indications of the structural nature of the control information extractor by providing the objectives and operations of the extractor within the invention. For example, the claim recites that the extractor configures the transmission information for the downlink control channel and that the controller controls the reception unit to receive the downlink control channel with a format corresponding to the transmission information. The Court understands that the extractor is providing the transmission information to the controller for the purpose of controlling the reception unit to receive data in the format provided by the transmission information. This suggests that § 112, ¶ 6 should not apply. *See, e.g., Linear Tech. Corp. v. Impala Linear Corp.*, 379 F.3d 1311, 1319–21 (Fed. Cir. 2004) ("circuit [for performing a function]"

found to be sufficiently definite structure because the claim recited the "objectives and operations" of the circuit); *Apple Inc. v. Motorola, Inc.*, 757 F.3d 1286, 1295, 1301 (Fed. Cir. 2014) ("heuristic [for performing a function]" found to be sufficiently definite structure in part because the claim described the operation and objectives of the heuristic); *Zeroclick, LLC v. Apple Inc.*, 891 F.3d 1003, 1008 (Fed. Cir. 2018) ("program that can [perform function]" found to be sufficiently definite structure in part because the claims provided operational context for the program); *Prisua Eng'g Corp.*, 948 F.3d at 1347–48, 1353–54 ("digital processing unit … performing [functions]" found to be sufficiently definite structure in part because the claims provided operational context for the unit). Further, the patent describes the extractor as structural: it is a component of a receiver that is connected to the controller and provides extracted control information to the controller. Finally, and while Defendant's expert has expressed a contrary view, Plaintiffs' expert has opined that "control information extractor" denoted structure at the relevant time period. (Mahon Decl. ¶¶ 93–99, Dkt. No. 82-7 at 43–46.) Given this context, Defendant has failed to overcome the presumption against application of § 112, ¶ 6.

Accordingly, the Court determines that Defendant has failed to establish that "control information extractor for configuring transmission information for the downlink control channel via higher layer signaling" should be governed by § 112, ¶ 6 or that Claim 37 is indefinite for including the term.

### B. U.S. Patent No. 8,019,332

The '332 Patent is entitled Method for Transmitting and Receiving Control Information Through PDCCH. The application leading to the '332 Patent was filed on December 8, 2010 and the patent states an earliest priority claim to a provisional application filed on February 19, 2008.

In general, the patent is directed to technology "for efficiently transmitting and receiving control information through a Physical Downlink Control Channel (PDCCH)." '332 Patent at

1:22–26. The patent generally describes an approach to limiting the Control Channel Elements (CCEs) available to User Equipment (UE) for the PDCCH in order to reduce search processing by the UE. Different UEs may be allocated different CCEs based on different starting positions for the PDCCH. *See*, *e.g.*, *id*. at 2:18–22, 5:26–47, 5:58–67.

The abstract of the ’332 Patent provides:

> A method for efficiently transmitting and receiving control information through a Physical Downlink Control Channel (PDCCH) is provided. When a User Equipment (UE) receives control information through a PDCCH, the received control information is set to be decoded in units of search spaces, each having a specific start position in the specific subframe. Here, a modulo operation according to a predetermined first constant value (D) is performed on an input value to calculate a first result value, and a modulo operation according to a predetermined first variable value (C) corresponding to the number of candidate start positions that can be used as the specific start position is performed on the calculated first result value to calculate a second result value and an index position corresponding to the second result value is used as the specific start position. Transmitting control information in this manner enables a plurality of UEs to efficiently receive PDCCHs without collisions.

Claim 6, an exemplary asserted claim from the ’332 Patent, is reproduced below with the terms in dispute emphasized:

> **6**. A user equipment (UE) for decoding control information, the UE comprising:
>
> a receiver for receiving a Physical Downlink Control Channel (PDCCH) from a base station at subframe k; and
>
> a decoder for decoding a set of PDCCH candidates within a search space of the PDCCH at the subframe k, wherein each of the set of PDCCH candidates comprises `L` control channel elements (CCEs),
>
> wherein the `L` CCEs corresponding to a specific PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position ***given by using a variable of $Y_k$ for the subframe k and a modulo `C` operation***, wherein `C` is determined as `floor(N/L)`, wherein `N` represents a total number of CCEs in the subframe k, and
>
> ***wherein $Y_k$ is defined by:***
>
> ***$Y_k=(A*Y_{k-1})\bmod D$***,
>
> wherein A, and D are predetermined constant values.

### B-1. "given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation"

| Disputed Term | Plaintiffs' Proposed Construction | Defendant's Proposed Construction |
|---|---|---|
| "given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation"<br><br>• '332 Patent Claims 1, 6 | no construction necessary | given by one of:<br>• $L \cdot [(A \cdot Y_k + B) \bmod D] \bmod C$ or<br>• $L \cdot (Y_k \bmod C)$ |

**The Parties' Positions**

Plaintiffs submit: The '332 Patent discloses multiple embodiments that are consistent with this claim term and limiting the term to Defendant's proposed equations would improperly exclude several of those embodiments. Further, dependent claims 4, 5, 9, and 10 each recite specific mathematical expressions for the term, indicating that the term itself should not be limited to any specific mathematical expression. Finally, it is not proper to limit this term to specific described embodiments based solely on an enablement argument—enablement is a distinct issue. (Dkt. No. 82 at 14–17.)

In addition to the claims themselves, Plaintiffs cite the following **extrinsic evidence** to support their position: Madisetti Decl.[9] ¶¶ 36–39 (Plaintiffs' Ex. 10, Dkt. No. 82-10); Lanning '332 Decl.[10] ¶ 125 (Plaintiffs' Ex. 11, Dkt. No. 82-11).

Defendant responds: The disputed term is set forth in the claims to denote how the start position for a candidate Physical Downlink Control Channel (PDCCH) is calculated. "[T]o satisfy the written description requirement, the claimed calculation must be one or more of [the formulas disclosed in the '332 Patent]." In the context of the claims, the start position is necessarily given as a CCE index rather than a CCE-aggregation index. As there are only two formulas provided in

[9] Declaration of Dr. Vijay Madisetti.
[10] Declaration of Mark Lanning Pursuant to Patent Local Rule 4-3(B): U.S. Patent No. 8,019,332.

the ’332 Patent for providing a start location as a CCE index using $Y_k$ and a modulo ‘C’ operation, the term should be limited to those two equations, denoted Expression 4 and Expression 6 in the patent. The dependent claims are consistent with this construction, as they further narrow the scope to only one of the formulas. (Dkt. No. 86 at 20–24.)

In addition to the claims themselves, Defendant cites the following intrinsic and extrinsic evidence to support its position: **Intrinsic evidence**: ’332 Patent at 7:22, 9:15–33, 9:56–61, 10: 3–8. **Extrinsic evidence**: Lanning ’332 Decl.[11] ¶¶ 51, 128–56 (Defendant’s Ex. 3, Dkt. No. 86-4); Madisetti Decl. ¶¶ 34–36, 39.

Plaintiffs reply: It would be improper to limit the claims to two of the exemplary embodiments, as Defendant proposes. Further, while dependent Claims 4 and 9 may be limited to a start position based on a CCE index, independent Claims 1 and 6 are not so limited. (Dkt. No. 92 at 8–9.)

**Analysis**

The issue in dispute distills to whether the claims should be limited to two exemplary embodiments of a formula for calculating a CCE start-position for a candidate PDCCH. They should not.

The Court declines to limit the claims to the disclosed embodiments identified by Defendant. To begin, the claims rather than the embodiments define the invention. *Phillips*, 415 F.3d at 1312, 1323 (“although the specification often describes very specific embodiments of the invention, we have repeatedly warned against confining the claims to those embodiments”). Defendant’s argument that limiting the claims to the embodiments is necessary to satisfy the written description and enablement requirements is not persuasive. (Dkt. No. 86 at 20–21; Lanning ’332 Decl. ¶ 133,

[11] This is the same declaration submitted by Plaintiffs as Dkt. No. 82-11.

Dkt. No. 86-4 at 45–46.) Determining whether written-description and enablement requirements are met is distinct from determining claim scope. *See Phillips*, 415 F.3d at 1327 ("we have certainly not endorsed a regime in which validity analysis is a regular component of claim construction"). Further, the patent need not disclose every embodiment that falls within the scope of the claims. *Toshiba Corp. v. Imation Corp.*, 681 F.3d 1358, 1369 (Fed. Cir. 2012) ("a patentee need not describe in the specification every conceivable and possible future embodiment of his invention" (quotation marks omitted)); *Rexnard Corp. v. Laitram Corp.*, 274 F.3d 1336, 1344 (Fed. Cir. 2001) (a patent "applicant is not required to describe in the specification every conceivable and possible future embodiment of his invention").

The Court is also not persuaded that the independent claims are necessarily limited to CCE-based units of measure. The '332 Patent teaches that the CCE search space may be defined by CCE aggregations or by CCE units. *See, e.g.*, '332 Patent at 9:5–27. In either case, the number of CCEs that are used to transmit one PDCCH, "$L_{CCE}$" or "L" in the patent, may be a factor in the defining the search space. For example, "mathematical expression 3" is directed to defining the start position of a CCE search space in terms of an aggregation index: "$Z_k = [(A \cdot y_k+B) \bmod D] \bmod C$." *Id*. at 8:7 – 9:13. The term "C" is elsewhere defined: "$C = \text{floor}(N_{CEE}/L_{CEE})$." *Id*. at col.7 ll.9–27. This start position may be redefined to denote "a corresponding position based on an index assigned to each CCE rather than an index assigned to each CCE aggregation" simply by multiplying the start position of "mathematical expression 3" by $L_{CEE}$ to yield "$Z_k = L_{CCE} \cdot [(A \cdot y_k+B) \bmod D] \bmod C$." *Id*. at 9:17–45 ("mathematical expression 4"). In other words, L contiguous CCEs (a CCE aggregation) are located by an aggregation index according to "mathematical expression 3" and equivalently by a CCE index according to "mathematical

expression 4," which includes a "L" multiplier. Dependent Claims 4, 5, 9, 10, 19, and 20 expressly recite determining a start position using this "L" multiplier. The independent claims do not.

Accordingly, the Court rejects Defendant's proposal to limit the claims to two specific exemplary embodiments and determines that "given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation" has its plain and ordinary meaning without the need for further construction.

### B-2. "wherein $Y_k$ is defined by: $Y_k$=(A*$Y_{k-1}$)mod D"

| Disputed Term | Plaintiffs' Proposed Construction | Defendant's Proposed Construction |
|---|---|---|
| "wherein $Y_k$ is defined by: $Y_k$=(A*$Y_{k-1}$)mod D"<br><br>• '332 Patent Claims 1, 6 | no construction necessary | indefinite |

**The Parties' Positions**

Plaintiffs submit: The '332 Patent provides guidance regarding the "types of initial values that can be used" in the sequence defined by $Y_k$=(A*$Y_{k-1}$)mod D and the claims need not specify an initial value to be definite. For example, the patent explains that the initial value may be provided by: "$Y_{-1}=n_{RNTI}\neq 0$ [where] $n_{RNTI}$ corresponds to a UE ID" (quoting '332 Patent at 9:62–63). Further, the claims are open ended, thus they may encompass a variety of unrecited initial values. Finally, the claims themselves do not need to be enabling, that is a function of the patent's technical disclosure. (Dkt. No. 82 at 17–22.)

In addition to the claims themselves, Plaintiffs cite the following intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '332 Patent Figs.8, 9, 11–14, 8:5–29, 9:56, 9:61–63, 10:21–22, 10:36–38; U.S. Patent No. 8,213,377; U.S. Patent No. 8,717,904.[12] **Extrinsic**

[12] U.S. Patents No. 8,717,904 and No. 8,213,377 are related to the '332 Patent through shared priority claims to U.S. Patent App. No. 12/252,270 (U.S. Patent No. 7,873,004).

**evidence**: Madisetti Decl. ¶¶ 23–32 (Plaintiffs' Ex. 10, Dkt. No. 82-10); Lanning '332 Decl. ¶ 29 (Defendant's Ex. 3, Dkt. No. 86-4).

Defendant responds: The equation $Y_k=(A*Y_{k-1})\text{mod } D$ is recursive in that a given value, $Y_k$, depends on a previous value, $Y_{k-1}$; thus, without specifying the starting point—i.e., the first $Y_k$—the meaning of $Y_k$ is not reasonably certain. (Dkt. No. 86 at 14–20.)

In addition to the claims themselves, Defendant cites the following intrinsic and extrinsic evidence to support its position: **Intrinsic evidence**: '332 Patent at 8:7–29, 9:62–63, 10:22–25, 10:32–43; U.S. Patent No. 7,973,004[13] (Defendant's Ex. 6, Dkt. No. 86-7); U.S. Patent No. 7,973,004 File Wrapper April 2, 2010 Preliminary Amendment (submitting translation of December 23, 2009 Notice of Submission of Opinion of the Korean Intellectual Property Office with Request for Participation in the Patent Prosecution Highway (PPH) Program) (Defendant's Ex. 5, Dkt. No. 86-6 at 39–58); U.S. Patent No. 8,717,904 File Wrapper (Defendant's Ex. 9, Dkt. No. 86-10); U.S. Patent No. 8,213,377 File Wrapper (Defendant's Ex. 10, Dkt. No. 86-11). **Extrinsic evidence**: Lanning '332 Decl. ¶¶ 31–39, 72–103, 110–21 (Defendant's Ex. 3, Dkt. No. 86-4); Madisetti Decl. ¶¶ 9–11, 27.

Plaintiffs reply: Like the variables A and D in the equation, which Defendant does not dispute can take on many different values without rendering the claims indefinite, $Y_{-1}$ can take on many different values without rendering the claims indefinite. (Dkt. No. 92 at 9–11.)

Plaintiffs cite further **extrinsic evidence** to support their position: Lanning '332 Decl. ¶¶ 117–18.

[13] The '332 Patent purports to be a continuation of the application that issued as U.S. Patent No. 7,873,004. '332 Patent, at [63] Related U.S. Application Data.

**Analysis**

The issue in dispute distills to whether claims directed to decoding within a search space "at subframe k" using a start position calculated using the variable $Y_k$, which has a value that depends on the variable's value for a previous subframe, k-1, are indefinite for failing to specify the ultimate beginning value of that variable (e.g., $Y_{-1}$). They are not.

What Defendant presents as an issue of indefiniteness the Court interprets as an issue of breadth. The '332 Patent is clear that the recursive function has an initial value. *See, e.g.*, '332 Patent at 8:14–29 (noting "$y_0 = x$" and "an initial value 'x' must be input"), 9:63–62 ("$Y_{-1} = n_{RNTI} \neq 0$"), 10:39–43 ("all of the following information items or combinations thereof can be used to create initial values [list]"). That the initial value may be any of a wide variety of values goes to breadth rather than indefiniteness. The Federal Circuit addressed a similar issue in *BASF Corp. v. Johnson Matthey Inc.*, 875 F.3d 1360 (Fed. Cir. 2017). There, the Federal Circuit criticized—and reversed—a district court that: "credit[ed] [the expert's] assertion that 'a practically limitless number of materials' could catalyze SCR of NOx, and … treat[ed] that scope as 'indicating that the claims, as written, fail to sufficiently identify the material compositions.'" *Id*. at 1367. The Federal Circuit held that "the inference of indefiniteness simply from the scope finding is legally incorrect: 'breadth is not indefiniteness.'" *Id*. (quoting *SmithKline Beecham Corp. v. Apotex Corp.*, 403 F.3d 1331, 1341 (Fed. Cir. 2005)). Ultimately, *BASF* held that "the claims and specification let the public know that any known SCR and AMOx catalysts can be used as long as they play their claimed role in the claimed architecture." *Id*. Here, the $Y_k$ is akin to the catalysts in *BASF*—the claims and the specification of the '332 Patent let the public know that any initial value may be used, so long as $Y_k$ plays its claimed role in the claimed process or device.

Accordingly, the Court determines that Defendant has not established that any claim is indefinite for including "wherein $Y_k$ is defined by: $Y_k=(A*Y_{k-1})\text{mod } D$" and determines that this term has its plain and ordinary meaning without the need for further construction.

### C. U.S. Patent No. 8,385,284

The '284 Patent is entitled Control Channel Signaling Using a Common Signaling Field for Transport Format and Redundancy Version. The application leading to the '284 Patent was filed on December 18, 2008 and the patent states an earliest priority claim to a foreign application filed on December 20, 2007.

In general, the patent is directed to technology for efficient use of control channels by reducing the amount of data (bits) needed to signal transport format and redundancy version for the associated user data. The patent discloses using a single field, the "control information field" to signal both transport format and redundancy. *See, e.g.*, '284 Patent at 6:57–7:14. In one embodiment of this field, the field is subdivided into two subsets: "a first subset of the values is reserved for indicating a transport format of the protocol data unit and a second subset of values are reserved for indicating a redundancy version for transmitting the user data." *Id*. at 7:36–46. The patent further provides that the first subset of values

> are used to indicate a transport format associated to a given fixed or preconfigured redundancy version (In this case one could speak of an explicit signaling of the transport format and a simultaneous implicit signaling of the redundancy version). All or part of the remaining values is used to indicate additional redundancy versions that may be for example used for retransmissions of the protocol data unit.

*Id*. at 15:29–41. The transport format may be indicated by, e.g., "the transport block size of the data (payload size, information bits size), the Modulation and Coding Scheme (MCS) level, the Spectral Efficiency, the code rate, etc." *Id*. at 3:29–4:3. Further, the patent instructs:

> in all embodiments of this invention the term "transport format" means either one of "transport format", "transport block size", "payload size" or "modulation and coding scheme". Similarly, in all embodiments of this invention the term

> "redundancy version" can be replaced by "redundancy version and/or constellation version".

*Id*. at 15:10–15.

The abstract of the '284 Patent provides:

> The invention relates to a method for providing control signalling associated to a protocol data unit conveying user data in a mobile communication system and to the control channel signal itself. Furthermore, the invention also provides a mobile station and a base station and their respective operation in view of the newly defined control channel signals defined herein. In order to reduce the control channel overhead, the invention suggests defining a common field for the transport format and redundancy version in the control channel information format. According to one approach, the common field is used to jointly encode transport format and redundancy version therein. According to another aspect, one shared field is provided on the control channel signal that indicates either a transport format or a redundancy version depending of whether the control channel signal relates to an initial transmission or a retransmission. In another embodiment, further enhancements to a HARQ protocol are suggested for addressing certain error cases.

Claim 1, an exemplary asserted claim from the '284 Patent, is reproduced below with the terms in dispute emphasized:

> **1.** A mobile terminal for use in a mobile communication system, the mobile terminal comprising:
>
> a receiver unit for receiving a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal,
>
> ***a processing unit for determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data***, and
>
> a transmitter unit for transmitting the protocol data unit on at least one physical radio resource using the transport format and the redundancy version of the protocol data unit indicated in the received control channel signal,
>
> wherein the control channel signal received within said sub-frame comprises a control information field, in which the transport format and the redundancy version of the protocol data unit are jointly encoded,
>
> ***wherein the processing unit is further configured for the determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field***, wherein a first subset of the values ***is reserved for indicating*** the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, ***is reserved for indicating*** the redundancy version for transmitting the user data, and

wherein the first subset of the values contains more values than the second subset of the values.

### C-1. "reserved for indicating"

| Disputed Term | Plaintiffs' Proposed Construction | Defendant's Proposed Construction |
|---|---|---|
| "reserved for indicating"<br><br>• '284 Patent Claims 1, 14 | no construction necessary<br><br>alternatively,<br>• kept, but not exclusively, for the purpose of identifying explicitly or implicitly | explicitly signals |

**<u>The Parties' Positions</u>**

Plaintiffs submit: The dispute here is similar to that addressed in Claim Construction Memorandum Opinion and Order, *Optis Wireless Tech., LLC v. Huawei Device Co. Ltd. et al.*,[14] 2:17-cv-123-JRG-RSP, Dkt. No. 114 (E.D. Tex. Jan. 18, 2018). There, the Court held that "reserved for indicating" held its plain and ordinary meaning and rejected that the term was limited to "is set aside just for," allowing that a subset of values may satisfy the limitation even if the subset indicates something in addition to the transport format or redundancy version that it is "reserved for indicating."[15] Here, the issue is whether a subset of values may implicitly indicate the transport format or redundancy version through correlation with an index rather than directly with a transport format or redundancy version. The '284 Patent explicitly teaches implicit indication and it would thus be improper to require explicit indication (citing, inter alia, '284 Patent 7:58–67, 8:36–39). (Dkt. No. 82 at 22–26.)

[14] The "*Huawei* Litigation."

[15] This term appears in the broader phrase "a first subset of values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data." '284 Patent at 28:65–29:2, 30:15–20.

In addition to the claims themselves, Plaintiffs cite the following intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: ’284 Patent at 7:47–67, 8:36–39, 14:4–6, 15:29–41, 15:53, 16:4–12, 16:23, 16:27, 16:46–51, 17:46–58, Tables 3–8 (17:1–20:49). **Extrinsic evidence**: Mahon Decl. ¶¶ 64–65 (Plaintiffs’ Ex. 7, Dkt. No. 82-7); Buehrer Decl.[16] ¶¶ 67–77 (Plaintiffs’ Ex. 14, Dkt. No. 82-14); Womack Decl.[17] ¶ 97 (Plaintiffs’ Ex. 15, Dkt. No. 82-15); Womack Trial Tr.[18] 77:12 – 79:12 (Plaintiffs’ Ex. 16, Dkt. No. 82-16 at 78–80).

Defendant responds: The ’284 Patent claims are directed to “joint encoding” and the patent teaches that for joint encoding a value that is reserved for indicating a parameter explicitly indicates what that parameter is, regardless of whether the value also implicitly indicates some other parameter or is used to explicitly indicate more than one parameter. “Nowhere does the patent disclose a value implicitly signaling a parameter that it is ‘reserved for indicating.’” In fact, Plaintiffs argued in the *Huawei* Litigation that because the “reserved for indicating” limitation required “explicit signaling,” the claims did not encompass prior art (citing Plaintiffs’ JMOL briefing and its expert’s testimony). Finally, allowing a subset of values reserved for indicating a parameter to implicitly indicate the parameter would exclude all the exemplary embodiments. Every disclosed indicating subset of values in the embodiments would implicitly or explicitly indicate the redundancy version and therefore would qualify as a subset “reserved for indicating” the redundancy version under Plaintiffs’ proposed construction. The claims, however, require that that subset reserved for indicating the transport format must be different than (contain more values

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[16] Declaration of Dr. R. Michael Buehrer in Support of Defendant Apple Inc.’s Claim Construction Brief.
[17] Rebuttal Expert Report of Dr. James E. Womack, Regarding Validity of U.S. Patent Nos. 8,208,569 and 8,385,284, *Optis Wireless Tech., LLC et al. v. Huawei Device USA, Inc. et al.*, 2:17-cv-123 (E.D. Tex.).
[18] Trial Tr., *Optis Wireless Tech., LLC et al. v. Huawei Device USA, Inc. et al.*, 2:17-cv-123 (E.D. Tex. Aug. 21, 2018).

than) the subset reserved for indicating the redundancy version, a limitation that none of the embodiments would satisfy under Plaintiffs' proposed construction. (Dkt. No. 86 at 24–28.)

In addition to the claims themselves, Defendant cites the following intrinsic and extrinsic evidence to support its position: **Intrinsic evidence**: '284 Patent at 7:47–65, 8:11–21, 8:33–39, 15:21–41, 15:52–60, 27:12–15, 27:31–34; '284 Patent File Wrapper Sept. 20, 2012 Amendment at 2, 5, 12 (Defendant's Ex. 13, Dkt. No. 86-14 at 4, 7, 14). **Extrinsic evidence**: Buehrer Decl.[19] ¶¶ 65–75 (Defendant's Ex. 2, Dkt. No. 86-3); Womack Decl.[20] ¶¶ 95–96, 105 (Defendant's Ex. 14, Dkt. No. 86-15); Womack Trial Tr.[21] 78:6 – 79:9, 141:10–17 (Defendant's Ex. 15, Dkt. No. 86-16 at 4–6); Plaintiffs' JMOL Response[22] at 13–15 & n.6 (Defendant's Ex. 16, Dkt. No. 86-17 at 3–5); U.S. Patent Application Publication No. 2013/0028212 (Defendant's Ex. 17, Dkt. No. 86-18); U.S. Patent Application Publication No. 2016/0323084 (Defendant's Ex. 18, Dkt. No. 86-19).

Plaintiffs reply: Even if the '284 Patent does not describe an embodiment of a value "reserved for indicating" a parameter that implicitly indicates the parameter, the plain meaning of "reserved for indicating" encompasses both implicit and explicit indicating. In fact, the patent supports implicit indicating with, e.g., "TF range" and "RV range," which may be "reserved for indicating." These ranges differ in that the TF range has a greater number of values than does the RV range, as specified in the claims. Finally, the issue in the *Huawei* Litigation was not whether "reserved for indicating" required explicit signaling, but rather whether Huawei correctly characterized the prior

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[19] This is the same declaration submitted by Plaintiffs as Dkt. No. 82-14.
[20] This is a subset of the declaration excerpts submitted by Plaintiffs as Dkt. No. 82-15.
[21] This is subset of the transcript submitted by Plaintiffs as Dkt. No. 82-16.
[22] Plaintiffs' Response to Huawei's Renewed Motion for Judgment as a Matter of Law, *Optis Wireless Tech., LLC v. Huawei Device Co. Ltd. et al.*, 2:17-cv-123-JRG-RSP, Dkt. No. 393 (E.D. Tex. May 3, 2019).

art as expressly signaling transport format or redundancy version and whether Claim 1 "permits explicit signaling for both transport format and redundancy version." (Dkt. No. 92 at 11–13.)

Plaintiffs cite further intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '284 Patent at 14:4–8, 17:54–59. **Extrinsic evidence**: Womack Decl. ¶¶ 95–96, 103, 105; Womack Trial Tr. 141:10–17; Mahon Decl. ¶¶ 72–75; Plaintiffs' JMOL Response at 13–15 & n.6.

**Analysis**

The issue in dispute distills to whether a subset of values that is "reserved for indicating" a parameter necessarily indicates the parameter by explicitly signaling the parameter. It does not.

The '284 Patent teaches both implicit and explicit signaling of parameters by reserved values. For example, the patent explains that "in general, the transport format defines the modulation and coding scheme (MCS) and/or the transport block size." '284 Patent at 13:49–50. Transport block size (TBS) and MCS are related such that the "control signaling may only need to indicate either the transport block size or the modulation and coding scheme." *Id*. at 13:64–66. Further, "transport block size is typically not explicitly signaled, but is rather signaled as a TBS index. The interpretation of the TBS index to determine the actual transport block size may for example depend on the resource allocation size." *Id*. at 14:4–8. In other words, the transport format may be implicitly indicated by explicitly signaling a TBS or a TBS index and then using a known relationship to determine the transport format.

The patent also teaches indicating a transport format (e.g., as described in the previous paragraph) and then using a known relationship between the transport format and redundancy version to determine the redundancy version. For example, a given value of a transport-format indicator may indicate a transport format "associated to a given fixed or preconfigured redundancy

version." The patent describes this as "explicit" signaling of transport format and "implicit" signaling of redundancy version. '284 Patent at 15:29–41. The patent describes a scheme in which values reserved for indicating the transport format indicate various transport format/redundancy version pairings and thus "implicitly" indicate a redundancy version, even allowing that "the same transport format may be associated to different redundancy versions." *Id*. at 17:26–64 ("Table 4" and accompanying description). This is contrasted with a value reserved for indicating a redundancy version that does not also express information about the transport format. *Id*. When using the later, "it may be assumed that the transport format is constant or known," but the transport format is not affirmatively stated by the value. *Id*.

In general, the explicit/implicit dichotomy does not clarify claim scope. For example, the patent suggests that using a value to indicate a parameter (e.g., TBS or MCS) from which one can determine transport format is "explicit" signaling of the transport format but at the same time suggests that the ability to determine redundancy version from the value is "implicit" signaling of redundancy version. In either case, the indicating value supports a determination through association rather than directly expressing the transport format or redundancy version. Indeed, Tables 3 through 8 each indicate the signaled value is used to determine (e.g., look up) a transport format and a redundancy version through association. For example, in Table 3, a signaled value of "1000" (binary) is associated with TBS=200 and RV=0. In Table 4, a signaled value of "1000" (binary) is associated with TBS=200 and RV=2. *Id*. at 17:1–44. The value "1000" is reserved for indicating a transport format but actually indicates both a transport format and a redundancy version. In contrast, a signaled value of "1110" (binary) is associated with RV=2 (Table 3) or RV=1 (Table 4) but is not associated with a transport format, even though the patent explains that "it may be assumed that the transport format is constant or known." *Id*. at 17:1–64. The value

"1110" is reserved for indicating a redundancy version and affirmatively states a redundancy version but does not affirmatively state a transport format.

Ultimately, implicit or explicit signaling is not a clarifying characteristic of values "reserved for indicating" a parameter. Rather, a common characteristic of the "reserved for indicating" values is that they affirmatively carry information about the parameter they are reserved for indicating, even though the affirmatively-carried information is associated with the parameter rather than stating the parameter directly. Thus, the plain meaning of "reserved for indicating" does not hinge on "explicit" or "implicit" signaling of the parameter, as the Court understands the parties to use those terms. Ultimately, whether a particular value, such as an index, satisfies the "reserved for indicating" limitation is an issue of fact for the jury.

Accordingly, the Court rejects both the "implicit" and "explicit" language suggested by the parties and determines that "reserved for indicating" has its plain and ordinary meaning without the need for further construction.

### C-2. "processing unit for … wherein the processing unit is further configured for …"

| Disputed Term | Plaintiffs' Proposed Construction | Defendant's Proposed Construction |
|---|---|---|
| "processing unit for determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and … wherein the processing unit is further configured for the determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data"<br><br>• '284 Patent Claim 1 | no construction necessary: not 35 U.S.C. § 112, ¶ 6, not indefinite<br><br>alternatively (if § 112, ¶ 6),<br>• **function 1**: determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data<br>• **structure 1**: hardware programmed, or hardware with software programmed, according to an algorithm in which a determination of the transport format and the redundancy version is made such as described at 10:21-34 by determining the data within a joint field of a transmission such as shown and described in Figure 5, 12:55-58, 22:45-59 and that data is correlated to the transport format and redundancy version via tables such as Tables 3-8, and equivalents thereof<br>• **function 2**: determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field<br>• **structure 2**: hardware programmed, or hardware with software programmed, according to algorithms in which a determination of the control information field is made by interpreting the control information field content, such as described in 6:65-8:54, 10:21-34, 12:55-58, 15:29-60, 16:46-21:3, 22:45-59, 27:61-28:12, Tables 3-8, Figs. 5, 8, 9, and equivalents thereof. | 35 U.S.C. § 112, ¶ 6, indefinite<br><br>• **function**: determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and determin[ing] of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field, wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data<br>• **structure**: indefinite |

**The Parties' Positions**

Plaintiffs submit: For the reasons Plaintiffs provided to the Court in the *Huawei* Litigation, this term should not be governed by 35 U.S.C. § 112, ¶ 6. Even if governed by § 112, ¶ 6, the '284 Patent satisfies the structural disclosure requirements of the statute. For example, the patent describes jointly encoding transport format and redundancy version in a 4-bit field in a control-channel signal. Examples of this encoding are provided in Tables 3 through 8 in the patent. The patent explains that this encoding methodology applies to transport block size (TBS) and modulation and coding scheme (MCS), since TBS and MCS are interrelated. Finally, the patent also explains that this encoding methodology applies to redundancy version (RV) and constellation version (CV), in that RV and CV are described as interchangeable. (Dkt. No. 82 at 26–30.)

In addition to the claims themselves, Plaintiffs cite the following intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '284 Patent Fig.5, 6:44–49, 6:65–8:54, 10:21–24, 12:55–58, 13:30–15:15, 15:29–60, 16:4–13, 16:46–21:3, 22:45–59, 27:61–28:12, Tables 3–8 (17:1–20:49). **Extrinsic evidence**: Mahon Decl. ¶¶ 38–39, 58–62, 79–81, 83–89, (Plaintiffs' Ex. 7, Dkt. No. 82-7); Buehrer Decl. ¶¶ 82–83, 87 (Plaintiffs' Ex. 14, Dkt. No. 82-14).

Defendant responds: The '284 Patent does not meet the disclosure requirements of § 112, ¶ 6 because it fails to provide structure for performing the fully recited functions. First, the look-up tables do not provide the requisite algorithms. Second, there is no disclosure of any algorithm for determining the MCS or CV. Since MCS falls within the scope of "transport format" as used in the patent, and CV falls within the scope of "redundancy version" as used in the patent, § 112, ¶ 6 requires that structure for "determining based on the received control channel signal a transport format of and a redundancy version …" be capable of determining MCS and CV. Since the patent

fails to disclose such structure, it does not satisfy the statute and Claim 1 is indefinite. (Dkt. No. 86 at 28–32.)

In addition to the claims themselves, Defendant cites the following intrinsic and extrinsic evidence to support its position: **Intrinsic evidence**: ’284 Patent at 3:29–4:8, 4:17–20, 14:1–4, 14:27–52, 15:10–15, 16:32–46, 17:53–65, 18:13–16, 26:46–27:20, Tables 3–8 (17:1–20:49). **Extrinsic evidence**: Buehrer Decl. ¶¶ 78–102 (Defendant’s Ex. 2, Dkt. No. 86-3).

Plaintiffs reply: The patent provides for mapping bit values to transport format and redundancy version combinations and further provides examples of this mapping with TBS and RV, exemplary transport format and redundancy version, respectively. The law does not require examples of every possible transport format and redundancy version and thus examples of mapping bit values to MCS and CV is not required by § 112, ¶ 6. Further, the structural disclosure requirement of the statute relates to the means for performing the recited function (the determining) rather than the object of the recited function (the transport format and redundancy version). (Dkt. No. 92 at 13–15.)

Plaintiffs cite further **intrinsic evidence** to support their position: ’284 Patent at 15:1–22:67.

**Analysis**

The issues in dispute are whether 35 U.S.C. § 112, ¶ 6 applies and whether the ’284 Patent discloses adequate structure if § 112, ¶ 6 does apply. Section 112, ¶ 6 applies and, as set forth below and in the *Huawei* claim-construction order, the ’284 Patent satisfies the disclosure requirements of the statute.

The Court addressed this term in the *Huawei* litigation even though it did not directly consider the “wherein the processing unit is further configured for …” clause. Claim Construction Memorandum Opinion and Order, *Optis Wireless Tech., LLC v. Huawei Device Co. Ltd. et al.*,

2:17-cv-123-JRG-RSP, Dkt. No. 114 at 59–67 (E.D. Tex. Jan. 18, 2018). The "wherein" clause does not alter the Court's *Huawei* analysis since the structure there identified by the Court satisfies the wherein clause. For example, Tables 3 through 8 all indicate a "number of bits representing a range of values that can be represented in the control information field" and further indicate a first subset of values reserved for indicating the transport format (the "TF range") and a second subset of values reserved for indicating the redundancy version (the "RV range") where there are more values in the TF range than in the RV range. '284 Patent at 17:1–20:50. The Court is not persuaded by either party's argument or evidence that the *Huawei* ruling was incorrect. Thus, the Court reiterates the *Huawei* ruling and reasoning and adopts the *Huawei* construction, with a clarification that the identified structure is not merely exemplary (other than through application of statutory equivalents).

Specifically, the Court is not persuaded: (1) that "processing unit" is not governed by § 112, ¶ 6 and (2) that "processing unit" is indefinite because it does not explicitly disclose structure tied to every species of "transport format" (including MCS) and to every species of "redundancy version" (including CV). With respect to whether "processing unit" is governed by § 112, ¶ 6, Plaintiff offers nothing more than a reference to its arguments and evidence presented in the *Huawei* litigation. With respect to the whether the patent satisfies the § 112, ¶ 6 disclosure requirements, it clearly describes structure for performing the recited functions (as set forth in the *Huawei* ruling). The Court does not understand § 112, ¶ 6 to require a description of the structure applied to every possible piece of information that may be input to or output from the structure. For example, the lookup tables provide an algorithm (structure) for determining transport format based on a control signal using the association between the control-signal value and format. *See, e.g.*, *Typhoon Touch Techs., Inc. v. Dell, Inc.*, 659 F.3d 1376, 1385 (Fed. Cir. 2011) ("the patent

need only disclose sufficient structure for a person of skill in the field to provide an operative software program for the specified function"). The patent need not describe every possible embodiment of such an association between a signal value and a transport format to satisfy § 112, ¶ 6. *See Toshiba Corp. v. Imation Corp.*, 681 F.3d 1358, 1369 (Fed. Cir. 2012) ("a patentee need not describe in the specification every conceivable and possible future embodiment of his invention" (quotation marks omitted)); *IMS Tech., Inc. v. Haas Automation, Inc.*, 206 F.3d 1422, 1432–34 (Fed. Cir. 2000) ("means to sequentially display data block inquiries" limited to the display structure but not to the exemplary data block inquiries). Ultimately, whether the structure disclosed for performing the claim-recited function (as set forth below) encompasses a prior-art or accused structure that determines MCS or RV is an issue of fact for the jury.

Accordingly, the Court construes "processing unit for determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and … wherein the processing unit is further configured for the determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data" under 35 U.S.C. § 112, ¶ 6 as follows:

- **function**: "determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and determining the control information field, which consists of a number of bits representing a range of values that can be represented in the control

information field, wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data"

- **structure**: "hardware programmed, or hardware with software programmed, according to an algorithm in which a determination of the transport format and the redundancy version is made as described at 10:21–34 by determining the data within a joint field of a transmission as shown and described in Figure 5, 12:55-58, 22:45–59 and that data is correlated to the transport format and redundancy version via Tables 3–8, and equivalents thereof"

### D. U.S. Patent No. 8,411,557

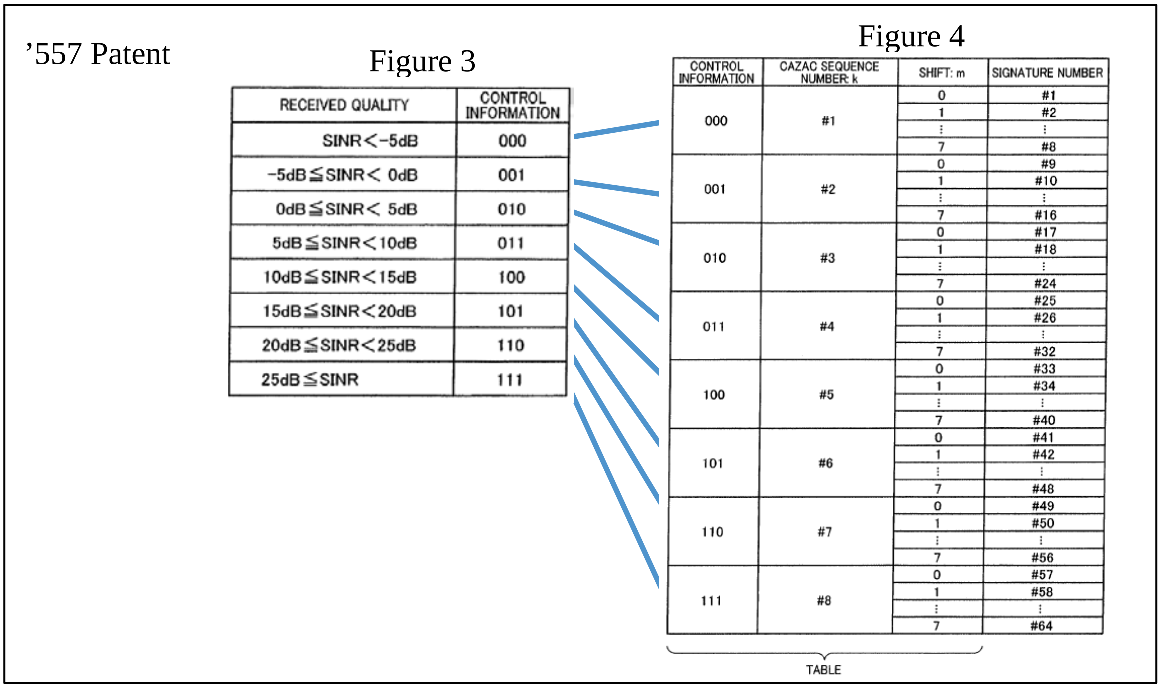
The '557 Patent is entitled Mobile Station Apparatus and Random Access Method. The application leading to the '557 Patent was filed on December 21, 2011 and the patent states an earliest priority claim to a foreign application filed on March 20, 2006.

In general, the patent is directed to technology for allowing a mobile communication device to report control information to the base station using the Random Access Channel ("RACH"). '557 Patent at 1:11–15, 1:54–2:22. The RACH is used, for example, for a mobile to request access to communication resources from the base station. *Id*. at 1:17–18. The RACH signal sent to the base station is a "signature" that distinguishes the sending mobile from other mobiles also sending RACH signals. *Id*. at 1:19–22. This signature may be one a series of code sequences that have low cross-correlation and high auto-correlation (e.g., Constant Amplitude Zero Auto-Correlation ("CAZAC") sequences). *Id*. at 1:23–32.

There are advantages to be gained if the mobile may use the RACH signal to report control information to the base station. *Id*. at 1:33–39. Such control information includes information such

as “mobile station ID, the reason for RACH transmission, bandwidth allocation request information (QoS information, the amount of data, and so on), and downlink received quality information.” *Id*. The invention of the ’557 Patent is meant to allow the mobile to efficiently report such control information in the RACH by establishing certain associations between code sequences and the control information that is to be reported to the base station. *Id*. at 1:54–2:22.

With reference to Figures 3 and 4, reproduced below and annotated by the Court, the patent describes an exemplary association between control information and CAZAC-sequence signatures. *Id*. at 4:54–5:24. In the example, the various potential values of the downlink “received quality” control information are separately associated with multiple CAZAC sequences. *Id*. In the example of Figure 4, the sequences associated with a particular received quality are derived from a common base CAZAC sequence (sequence number k) through application of shift values (shift m). *Id*. The mobile selects as its RACH signature one of the sequences associated with the control information it wishes to report. *Id*. at 5:25–44. Thus, the base station can identify the mobile and the control information from a single RACH signal sent from the mobile. *Id*. To alleviate the interference of multiple mobiles sending the same signature (collisions), the mobile preferably randomly selects the signature sequence from the series of appropriate sequences. *Id*. at 5:45–61.



’557 Patent

Figure 3

| RECEIVED QUALITY | CONTROL INFORMATION |
|---|---|
| SINR<−5dB | 000 |
| −5dB≦SINR< 0dB | 001 |
| 0dB≦SINR< 5dB | 010 |
| 5dB≦SINR<10dB | 011 |
| 10dB≦SINR<15dB | 100 |
| 15dB≦SINR<20dB | 101 |
| 20dB≦SINR<25dB | 110 |
| 25dB≦SINR | 111 |

Figure 4

| CONTROL INFORMATION | CAZAC SEQUENCE NUMBER: k | SHIFT: m | SIGNATURE NUMBER |
|---|---|---|---|
| 000 | #1 | 0 | #1 |
| | | 1 | #2 |
| | | ⋮ | ⋮ |
| | | 7 | #8 |
| 001 | #2 | 0 | #9 |
| | | 1 | #10 |
| | | ⋮ | ⋮ |
| | | 7 | #16 |
| 010 | #3 | 0 | #17 |
| | | 1 | #18 |
| | | ⋮ | ⋮ |
| | | 7 | #24 |
| 011 | #4 | 0 | #25 |
| | | 1 | #26 |
| | | ⋮ | ⋮ |
| | | 7 | #32 |
| 100 | #5 | 0 | #33 |
| | | 1 | #34 |
| | | ⋮ | ⋮ |
| | | 7 | #40 |
| 101 | #6 | 0 | #41 |
| | | 1 | #42 |
| | | ⋮ | ⋮ |
| | | 7 | #48 |
| 110 | #7 | 0 | #49 |
| | | 1 | #50 |
| | | ⋮ | ⋮ |
| | | 7 | #56 |
| 111 | #8 | 0 | #57 |
| | | 1 | #58 |
| | | ⋮ | ⋮ |
| | | 7 | #64 |

TABLE

With reference to Figure 11, reproduced herein and annotated by the Court, the patent also describes a dynamically generated association between the control information and code sequences. *Id.* at 8:27–9:3. To account for variances in the number of mobiles reporting the same control information, the mobile may use information about the rates of occurrence of the particular pieces of control information to alter the association between the control information and the sequences. *Id.* This allows for more sequences to be associated with high-occurrence control information (those that are reported from many mobiles) and for fewer to be associated with low-occurrence control information. *Id.* This reduces the rate of collisions (multiple mobiles sending the same signature sequence). *Id.* at 7:50–67. The information regarding the rate of occurrence of the various pieces of control information is provided by the base station via a “control signal.” *Id.* at 8:42–51.

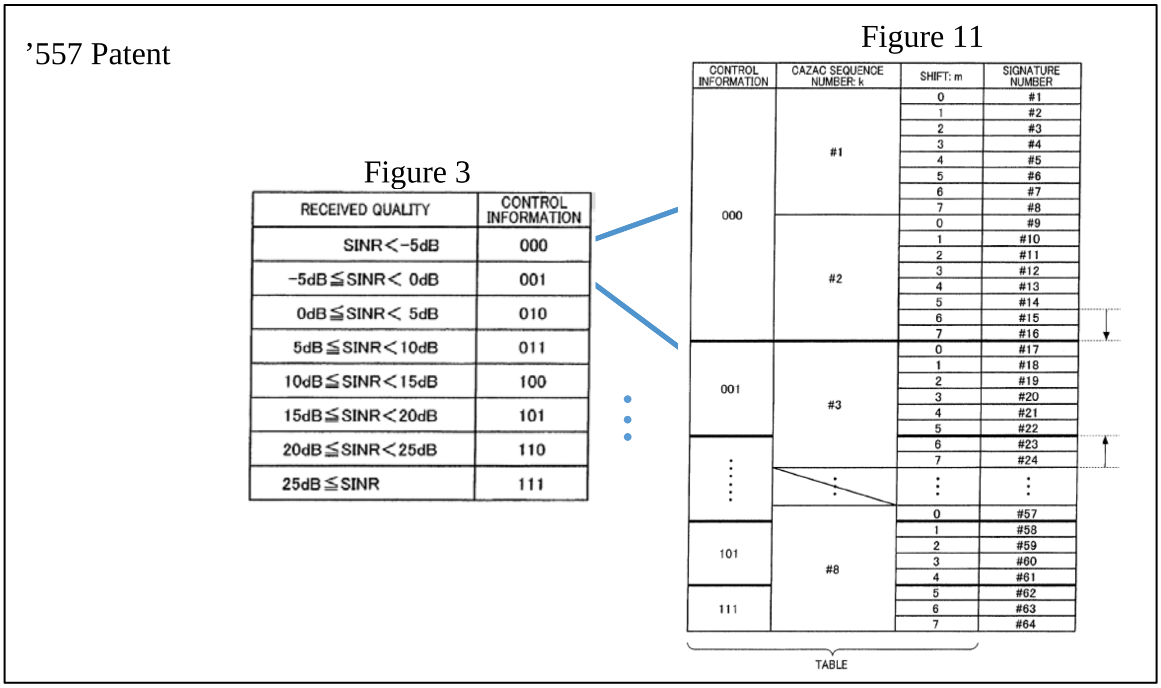

’557 Patent

Figure 3

| RECEIVED QUALITY | CONTROL INFORMATION |
|---|---|
| SINR<−5dB | 000 |
| −5dB≦SINR< 0dB | 001 |
| 0dB≦SINR< 5dB | 010 |
| 5dB≦SINR<10dB | 011 |
| 10dB≦SINR<15dB | 100 |
| 15dB≦SINR<20dB | 101 |
| 20dB≦SINR<25dB | 110 |
| 25dB≦SINR | 111 |

Figure 11

| CONTROL INFORMATION | CAZAC SEQUENCE NUMBER: k | SHIFT: m | SIGNATURE NUMBER |
|---|---|---|---|
| 000 | #1 | 0 | #1 |
| | | 1 | #2 |
| | | 2 | #3 |
| | | 3 | #4 |
| | | 4 | #5 |
| | | 5 | #6 |
| | | 6 | #7 |
| | | 7 | #8 |
| | #2 | 0 | #9 |
| | | 1 | #10 |
| | | 2 | #11 |
| | | 3 | #12 |
| | | 4 | #13 |
| | | 5 | #14 |
| | | 6 | #15 |
| | | 7 | #16 |
| 001 | #3 | 0 | #17 |
| | | 1 | #18 |
| | | 2 | #19 |
| | | 3 | #20 |
| | | 4 | #21 |
| | | 5 | #22 |
| | | 6 | #23 |
| | | 7 | #24 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| | #8 | 0 | #57 |
| 101 | | 1 | #58 |
| | | 2 | #59 |
| | | 3 | #60 |
| | | 4 | #61 |
| 111 | | 5 | #62 |
| | | 6 | #63 |
| | | 7 | #64 |

TABLE

The abstract of the ’557 Patent provides:

> A mobile station apparatus includes a receiving unit configured to receive control information; a selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities; and a transmitting unit for transmitting the selected sequence. The predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts. A position at which the predetermined number of sequences are partitioned is determined based on the control information, and a number of sequences contained in each of the plurality of groups varies in accordance with the control information.

Claim 1, an exemplary asserted claim from the ’557 Patent, is reproduced below with the term in dispute emphasized:

> **1.** A mobile station apparatus comprising:
> a receiving unit configured to receive control information;
> a ***selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined***

***number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts***; and

a transmitting unit configured to transmit the selected sequence,

wherein a position at which the predetermined number of sequences are partitioned is determined based on the control information, and a number of sequences contained in each of the plurality of groups varies in accordance with the control information.

**D-1. "selecting unit configured to …"**

| Disputed Term | Plaintiffs' Proposed Construction | Defendant's Proposed Construction |
|---|---|---|
| "selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts"<br><br>• '557 Patent Claim 1 | plain and ordinary meaning, not 35 U.S.C. § 112, ¶ 6, not indefinite<br><br>alternatively (if § 112, ¶ 6),<br>• **function**: randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts<br>• **structure**: Figs. 1 (111), 4, 5, 8, 9, 10 (111), col./line 1:65-2:7, 2:57-67, 3:18-7:49, 4:57-4:67, 5:19-6:5, 8:55-9:3, 9:6-12 and/or equivalents thereof | 35 U.S.C. § 112, ¶ 6, indefinite<br><br>• **function**: randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts<br>• **structure**: indefinite |

**<u>The Parties' Positions</u>**

Plaintiffs submit: The dispute here was previously addressed in Memorandum Opinion and Order, *Optis Wireless Tech., LLC v. ZTE Corporation et al.*,[23] 2:15-cv-300-JRG-RSP, Dkt. No. 116 (E.D. Tex. Apr. 20, 2016). There, the Court determined that the "selecting unit …" limitation was not governed by 35 U.S.C. § 112, ¶ 6. The Court's previous construction of this term is justified because "selecting unit" is used in the '557 Patent and the prior art to denote specific structure. Further, the claim sets forth the objectives and operations of the selecting unit in such detail as to convey its structural nature. Finally, even if § 112, ¶ 6 governs, the patent satisfies the statute in that is specifies "a specific arrangement of sequences, the grouping of the sequences, and the selection of a sequence from one of the groups" and "signature selecting section 111, which is described in multiple embodiments in the specification, both graphically, as it interacts with the other components in the system in Figs. 1 and 10, as well as verbally, down to complex mathematical equations that may be used to generate sequences." (Dkt. No. 82 at 31–35.)

In addition to the claims themselves, Plaintiffs cite the following intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '557 Patent Figs.1, 4, 5, 9–11, 1:65–2:7, 2:57–67, 3:18–7:49, 8:55–9:3, 9:6–12, 9:26–48; U.S. Patent Application Publication 2010/0278114 (Plaintiffs' Ex. 19, Dkt. No. 82-19); U.S. Patent Application Publication 2008/0192678 (Plaintiffs' Ex. 20, Dkt. No. 82-20). **Extrinsic evidence**: Madisetti Decl. ¶¶ 43–46 (Plaintiffs' Ex. 10, Dkt. No. 82-10).

Defendant responds: The term "selecting unit" is a nonce term rather than a name for specific structure that performs the recited function and the term, therefore, is governed by 35 U.S.C. § 112, ¶ 6. As the "selecting unit" is computer implemented, the '557 Patent must disclose an algorithm

[23] The "*ZTE* Litigation."

for performing the recited function to satisfy the statue. Instead, the patent merely repeats the function when describing the "selecting unit." As such, Claim 1 of the '557 Patent is indefinite. (Dkt. No. 86 at 33–36.)

In addition to the claims themselves, Defendant cites the following intrinsic and extrinsic evidence to support its position: **Intrinsic evidence**: '557 Patent Figs.1, 10, 2:62–65, 4:57–67, 5:25–35, 5:45–61, 5:63–6:5; U.S. Patent Application Publication 2010/0278114 (Plaintiffs' Ex. 19, Dkt. No. 82-19); U.S. Patent Application Publication 2008/0192678 (Plaintiffs' Ex. 20, Dkt. No. 82-20). **Extrinsic evidence**: Lanning '557 Decl.[24] ¶¶ 41–43, 46, 47, 49–56, 59 (Defendant's Ex. 23, Dkt. No. 93-1); U.S. Patent No. 7,107,056 (Defendant's Ex. 24, Dkt. No. 86-25); U.S. Patent No. 5,732,334 (Defendant's Ex. 25, Dkt. No. 86-26); U.S. Patent No. 6,311,059 (Defendant's Ex. 26, Dkt. No. 86-27); U.S. Patent No. 6,073,024 (Defendant's Ex. 27, Dkt. No. 86-28).

Plaintiffs reply: In the context of the claims and description of the '557 Patent, "selecting unit" is sufficiently structural. (Dkt. No. 92 at 15–16.)

Plaintiffs cite further **extrinsic evidence** to support their position: Madisetti Decl. ¶¶ 41–47.

**<u>Analysis</u>**

The issues in dispute are whether 35 U.S.C. § 112, ¶ 6 applies and whether the '557 Patent discloses adequate structure if § 112, ¶ 6 applies. Because the Court finds that 35 U.S.C. § 112, ¶ 6 does not apply, it does not reach the second issue.

This is substantially the same issue before the Court in the *ZTE* Litigation. The Court is not persuaded by Defendant's argument and evidence that the *ZTE* ruling was incorrect. Specifically,

[24] Declaration of Mark Lanning Pursuant to Patent Local Rule 4-3(B): U.S. Patent Number 8,411,557

given the presumption against application of § 112, ¶ 6 and Federal Circuit instruction regarding denoting the structural nature of a claim term by reciting its operational context within the claimed invention (as described above in Section A-1), the Court reiterates the *ZTE* ruling and reasoning and rejects Defendant's arguments that the "selecting unit …" term renders any claim indefinite. *See Optis Wireless Tech., LLC v. ZTE Corporation et al.*, 2:15-cv-300-JRG-RSP, Dkt. No. 116 at 82–87 (E.D. Tex. Apr. 20, 2016).

Accordingly, the Court determines that this term is not governed by 35 U.S.C. § 112, ¶ 6 and needs no further construction.

### E. U.S. Patent No. 9,001,774

The '774 Patent is entitled System and Method for Channel Estimation in a Delay Diversity Wireless Communication System. The application leading to the '774 Patent was filed on November 12, 2013 and the patent states an earliest priority claim to a provisional application filed on April 21, 2005.

In general, the patent is directed to technology "for performing channel estimation in an orthogonal frequency division multiplexing (OFDM) network or an orthogonal frequency division multiple access (OFDMA) network." '774 Patent at 1:32–37. The patent builds off a "technique for artificially introducing frequency diversity into an OFDM environment" in which "multiple copies of the same OFDM symbol are delayed by different delay values, then amplified by the same or different gain values, and then transmitted from different antennas." *See id*. at 1:41–60. The patent teaches using an uplink signal to estimate the quality of a channel between a base station and a subscriber station, and to use that estimate to determine a parameter set used to establish the delay values and gains values. *Id*. at 2:43–59. Part of the communication in such a system is using the parameter set on received information to reverse the frequency-diversity processing ("compensating" for the processing). *Id*. at 9:32–10:17. "[T]he compensation can either be done

on the time domain OFDM symbol or directly in the frequency domain. … a time delay in the time domain translates into a phase rotation in the frequency domain." *Id*. at 10:18–30.

The abstract of the '774 Patent provides:

> A method of controlling downlink transmissions to a subscriber station capable of communicating with a base station of an orthogonal frequency division multiplexing (OFDM) network. The method comprises the steps of: receiving a first pilot signal from a first base station antenna; receiving a second pilot signal from a second base station antenna; and estimating the channel between the base station and subscriber station based on the received first and second pilot signals. The method also comprises determining a set of OFDM symbol processing parameters based on the step of estimating the channel and transmitting the OFDM symbol processing parameters to the base station. The base station uses the OFDM symbol processing parameters to control the relative gains and the relative delays of OFDM symbols transmitted from the first and second antennas.

Claim 6, an exemplary asserted claim from the '774 Patent, is reproduced below with the term in dispute emphasized:

> **6**. A method, comprising:
> receiving a processing parameter for transmission of data on two antenna ports, the processing parameter including ***at least one of a time delay, a phase rotation and a gain*** determined based on a received uplink signal;
> receiving a first pilot, a second pilot, a first data symbol and a second data symbol transmitted on the two antenna ports; and
> demodulating the first data symbol and the second data symbol based on the processing parameter, the first pilot and the second pilot.

### E-1. "at least one of a time delay, a phase rotation and a gain"

| Disputed Term | Plaintiffs' Proposed Construction | Defendant's Proposed Construction |
|---|---|---|
| "at least one of a time delay, a phase rotation and a gain"<br><br>• '774 Patent Claim 6 | no construction necessary, this is a disjunctive list not requiring at least one of all three listed items | at least one time delay, at least one phase rotation, and at least one gain |

**The Parties' Positions**

Plaintiffs submit: As explained in the '774 Patent, any of "time delay," "phase rotation," and "gain" may be used as recited in the claim. In fact, "phase rotation" is described as an alternative

to "time delay," and is not described as a parameter in addition to "time delay." In this context, "at least one of a time delay, a phase rotation and a gain" should be construed as a disjunctive list. (Dkt. No. 82 at 35–38.)

In addition to the claims themselves, Plaintiffs cite the following intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '774 Patent Fig.3, 10:21–30. **Extrinsic evidence**: Mahon Decl. ¶¶ 117–26 (Plaintiffs' Ex. 7, Dkt. No. 82-7).

Defendant responds: A plain reading of "at least one of a time delay, a phase rotation and a gain" is, by reason of the "and," a conjunctive list. Thus, the claim requires at least one of each member in the list. This comports with the description of the invention, which indicates multiple parameters in every embodiment and never suggests that a single parameter may be used. (Dkt. No. 86 at 36–39.)

In addition to the claims themselves, Defendant cites the following **intrinsic evidence** to support its position: '774 Patent at 1:61–62, 4:11–13, 7:52–55, 10:22–28.

Plaintiffs reply: The embodiment depicted in Figure 3 uses a single processing parameter, gain. Ultimately, a conjunctive interpretation of the list is inconsistent with the description of the invention. (Dkt. No. 92 at 16–17.)

Plaintiffs cite further **intrinsic evidence** to support their position: '774 Patent at 7:3–5.

**Analysis**

The issue in dispute is whether "at least one of a time delay, a phase rotation and a gain" requires at least one of each member of the list, or only at least one of the members of the list. In the context of the '774 Patent, the term requires at least one time delay, at least one phase rotation, or at least one gain. That is, while it encompasses at least one of each, it does not require one of each.

The Court agrees with Plaintiffs that the '774 Patent teaches time delays and phase rotations as alternatives, and that this suggests a disjunctive reading of the list. Specifically, the patent provides:

> In an OFDM system, the pilot and data symbols are carried on OFDM subcarriers. Therefore, the ***compensation can <u>either</u> be done on the time domain OFDM symbol or directly in the frequency domain***. In order to do compensation in the frequency domain, the [e]ffect of OFDM symbol delay in the time-domain must be accounted for in the frequency domain. In general, ***a time delay in the time domain translates into a phase rotation in the frequency domain***. Therefore, the OFDM subcarriers carrying the pilot symbols may be appropriately phase rotated in the frequency domain to account for time delays.

'774 Patent at 10:20–30 (emphasis added). Requiring both a time delay and a phase rotation as Defendant proposes would require working in both the time domain and the frequency domain, in contradiction to the patent's teaching that the processing is done "either" in the time domain or frequency domain. The claims should be construed in the context of the patent's teaching that time delay and phase rotation are alternatives. "The claims are directed to the invention that is described in the specification; they do not have meaning removed from the context from which they arose." *Phillips*, 415 F.3d at 1316 (quoting *Netword, LLC v. Centraal Corp.*, 242 F.3d 1347, 1352 (Fed. Cir. 2001)). "The only meaning that matters in claim construction is the meaning in the context of the patent." *Trs. of Columbia Univ. v. Symantec Corp.*, 811 F.3d 1359, 1363 (Fed. Cir. 2016). In this context, the Court understands "at least one of a time delay, a phase rotation and a gain" to be disjunctive.

Accordingly, the Court construes "at least one of a time delay, a phase rotation and a gain" as follows:

- "at least one of a time delay, a phase rotation and a gain" means "at least one time delay, at least one phase rotation, or at least one gain."

### F. U.S. Patent No. 8,102,833

The ’833 Patent is entitled Method for Transmitting Uplink Signals. The application leading to the ’833 Patent was filed on September 11, 2008 and the patent states an earliest priority claim to a provisional application filed on September 13, 2007.

In general, the patent is directed to technology for transmitting uplink control signals, including specifically ACK and NACK signals. The patent teaches mapping multiplexed control and data signals to physical communication resources (e.g., symbols and subcarriers), and then overwriting some of the information in the resource region with ACK/NACK signals. *See, e.g.*, ’774 Patent at 2:15–32. As explained in the patent, in this context "‘overwritten’ means that specific information mapped in the resource region is skipped and the corresponding region is mapped. Also, ‘overwritten’ means that the length of the entire information is maintained equally even after specific information is inserted." *Id.* at 6:9–21.

The abstract of the ’833 Patent provides:

> A method for transmitting uplink signals, which include ACK/NACK signals, control signals other than the ACK/NACK signals, and data signals, is disclosed. The method comprises serially multiplexing the control signals and the data signals; sequentially mapping the multiplexed signals within a specific resource region in accordance with a time-first mapping method, the specific resource region including a plurality of symbols and a plurality of virtual subcarriers; and arranging the ACK/NACK signals at both symbols near symbols to which a reference signal of the plurality of symbols is transmitted. Thus, the uplink signals can be transmitted to improve receiving reliability of signals having high priority.

Claim 1, an exemplary asserted claim from the ’833 Patent, is reproduced below with the term in dispute emphasized:

> **1**. A method for transmitting uplink signals comprising control signals and data signals in a wireless communication system, the method comprising:
> (a) serially multiplexing first control signals and data signals in a mobile station, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals;

(b) mapping the multiplexed signals to a 2-dimensional resource matrix comprising a plurality of columns and a plurality of rows, wherein the columns and the rows of the 2-dimensional resource matrix correspond to single carrier frequency divisional multiple access (SC-FDMA) symbols and subcarriers for each SC-FDMA symbol, respectively, wherein a number of columns of the 2-dimensional resource matrix corresponds to a number of SC-FDMA symbols within one subframe except specific SC-FDMA symbols used for a reference signal, and wherein the multiplexed signals are mapped from the first column of the first row to the last column of the first row, the first column of the second row to the last column of the second row, and so on, until all the multiplexed signals are mapped to the 2-dimensional resource matrix

(c) mapping ACK/NACK control signals to specific columns of the 2-dimensional resource matrix, wherein the specific columns correspond to SC-FDMA symbols right adjacent to the specific SC-FDMA symbols, wherein ***the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix at step (b) from the last row of the specific columns***; and

(d) transmitting the signals mapped to the 2-dimensional resource matrix at steps (b) and (c) by column by column to a base station.

### F-1. "the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix [at step (b)] from the last row of the specific columns"

<table>
<tr><th>Disputed Term</th><th>Plaintiffs' Proposed Construction</th><th>Defendant's Proposed Construction</th></tr>
<tr><td>"the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix at step (b) from the last row of the specific columns"<br><br>• '833 Patent Claims 1</td><td rowspan="2">(1) some of the multiplexed signals, from the last row of the specific columns of the 2-dimensional resource matrix, are skipped and the corresponding ACK/NACK signals are mapped, and (2) the length of the entire information is maintained equally even after the ACK/NACK control signals are inserted</td><td rowspan="2">(1) some of the multiplexed signals, beginning from the last row of the specific columns of the 2-dimensional resource matrix, are skipped and the corresponding ACK/NACK signals are mapped, and (2) the length of the entire information is maintained equally even after the ACK/NACK control signals are inserted</td></tr>
<tr><td>"the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix from the last row of the specific columns"<br><br>• '833 Patent Claim 8</td></tr>
</table>

Because the parties' arguments and proposed constructions with respect to these terms are related, the Court addresses the terms together.

**The Parties' Positions**

Plaintiffs submit: The dispute here was previously addressed in the Claim Construction Memorandum Opinion and Order, *Optis Cellular Tech., LLC v. Kyocera Corp. et al.*,[25] 2:16-cv-59-JRG-RSP (Lead Case), Dkt. No. 108 (E.D. Tex. Feb. 19, 2017). There, the Court rejected the "beginning" language proposed by Defendant here and held that the terms do not mandate a starting position. The Court's construction in the *Kyocera* Litigation was agreed to by the parties in the *Huawei* Litigation.[26] This construction is correct because nothing in the intrinsic record rises to lexicography or disclaimer requiring a specific starting point for the claimed overwriting. Rather, the claims simply require that the ACK/NACK control signals overwrite data "from the last row," regardless of where the overwriting begins. (Dkt. No. 82 at 38–40.)

In addition to the claims themselves, Plaintiffs cite the following intrinsic and extrinsic evidence to support their position: **Intrinsic evidence**: '833 Patent Fig.6. **Extrinsic evidence**: Madisetti Decl. ¶¶ 48–52 (Plaintiffs' Ex. 10, Dkt. No. 82-10).

Defendant responds: As Plaintiffs argued and their expert opined in the *Kyocera* Litigation, the overwriting "begins in the last row of the matrix." This is the correct interpretation of the claim language as it recites overwriting "from" the last row rather than "in" the last row. This is how the patent applicant explained the claim language during prosecution, when it was added to distinguish the claims from prior art. Specifically, the applicant explained that one "can reduce the probability

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[25] The "*Kyocera* Litigation."
[26] *Optis Wireless Tech., LLC v. Huawei Device Co. Ltd. et al.*, 2:17-cv-123-JRG-RSP (E.D. Tex.).

that the first control signals are overwritten" by overwriting "from the last row." This is also how the Plaintiffs explained the prosecution history in the *Kyocera* Litigation. (Dkt. No. 86 at 40–43.)

In addition to the claims themselves, Defendant cites the following intrinsic and extrinsic evidence to support its position: **Intrinsic evidence**: '833 Patent File Wrapper September 6, 2011 Amendment at 2–3, 6, 10 (Defendant's Ex. 35, Dkt. No. 86-36 at 3–4, 7, 11). **Extrinsic evidence**: Wells Decl.[27] ¶¶ 46–47, 52–55 (Defendant's Ex. 33, Dkt. No. 86-34); Akl. Decl.[28] ¶ 45 (Defendant's Ex. 34, Dkt. No. 86-35); Madisetti Decl. ¶¶ 48–52.

Plaintiffs reply: The same evidence and argument presented here were considered and rejected by the Court in the *Kyocera* Litigation. While Plaintiffs originally proposed the argument and evidence in the *Kyocera* Litigation, they recognize the *Kyocera* construction is correct and agreed to it in the *Huawei* Litigation. Ultimately, the overwriting in the last row does not necessarily come before overwriting in other rows. (Dkt. No. 92 at 17–18.)

**Analysis**

The issue in dispute is whether "ACK/NACK control signals overwrite [data] . . . from the last row" necessarily means the data in the last row is overwritten before data in any other row is overwritten. It does not.

This issue was addressed by the Court in the *Kyocera* Litigation. The Court is not persuaded by Defendant's argument and evidence that the *Kyocera* ruling was incorrect. Thus, the Court reiterates the *Kyocera* ruling and reasoning and rejects Defendant's arguments that the overwriting necessarily begins in the last row of the matrix. *See Optis Cellular Tech., LLC v. Kyocera Corp. et al.*, 2:16-cv-59-JRG-RSP (Lead Case), Dkt. No. 108 at 31–36 (E.D. Tex. Feb. 19, 2017).

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[27] Declaration of Jonathan Wells, Ph.D., Pursuant to Patent Local Rule 4-3(B).
[28] Declaration of Dr. Robert Akl, D.Sc. Regarding Claim Construction, *Optis Cellular Tech., LLC et al. v. Blackberry Corp. et al.*, 2:16-cv-59-JRG-RSP (Lead Case) (E.D. Tex.)

Accordingly, the Court construes these terms as follows:

- "the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix at step (b) from the last row of the specific columns" means "(1) some of the multiplexed signals, from the last row of the specific columns of the 2-dimensional resource matrix, are skipped and the corresponding ACK/NACK signals are mapped, and (2) the length of the entire information is maintained equally even after the ACK/NACK control signals are inserted"; and
- "the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix from the last row of the specific columns" means "(1) some of the multiplexed signals, from the last row of the specific columns of the 2-dimensional resource matrix, are skipped and the corresponding ACK/NACK signals are mapped, and (2) the length of the entire information is maintained equally even after the ACK/NACK control signals are inserted"

## V. CONCLUSION

The Court adopts the constructions set forth above, as summarized in the following table. The parties are **ORDERED** that they may not refer, directly or indirectly, to each other's claim-construction positions in the presence of the jury. Likewise, the parties are **ORDERED** to refrain from mentioning any portion of this opinion, other than the actual definitions adopted by the Court, in the presence of the jury. Any reference to claim-construction proceedings is limited to informing the jury of the definitions adopted by the Court.

| Section | Term | Construction |
|---|---|---|
| **A-1** | "control information extractor for configuring transmission information for the downlink control channel via higher layer signaling"<br><br>• '154 Patent Claim 37 | not § 112, ¶ 6; plain and ordinary meaning |
| **B-1** | "given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation"<br><br>• '332 Patent Claims 1, 6 | plain and ordinary meaning |
| **B-2** | "wherein $Y_k$ is defined by: $Y_k$=(A*$Y_{k-1}$)mod D"<br><br>• '332 Patent Claims 1, 6 | plain and ordinary meaning |
| **C-1** | "reserved for indicating"<br><br>• '284 Patent Claims 1, 14 | plain and ordinary meaning |

| Section | Term | Construction |
|---|---|---|
| **C-2** | "processing unit for determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and … wherein the processing unit is further configured for the determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field"<br><br>• '284 Patent Claim 1 | • **function**: determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and determining the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field, wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data<br>• **structure**: hardware programmed, or hardware with software programmed, according to an algorithm in which a determination of the transport format and the redundancy version is made as described at 10:21-34 by determining the data within a joint field of a transmission as shown and described in Figure 5, 12:55-58, 22:45-59 and that data is correlated to the transport format and redundancy version via Tables 3-8, and equivalents thereof |

| Section | Term | Construction |
|---|---|---|
| **D-1** | "selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts"<br><br>• ’557 Patent Claim 1 | not § 112, ¶ 6; plain and ordinary meaning |
| **E-1** | "at least one of a time delay, a phase rotation and a gain"<br><br>• ’774 Patent Claim 6 | "at least one time delay, at least one phase rotation, or at least one gain" |
| **F-1** | "the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix at step (b) from the last row of the specific columns"<br><br>• ’833 Patent Claims 1 | "(1) some of the multiplexed signals, from the last row of the specific columns of the 2-dimensional resource matrix, are skipped and the corresponding ACK/NACK signals are mapped, and (2) the length of the entire information is maintained equally even after the ACK/NACK control signals are inserted" |
| | "the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix from the last row of the specific columns"<br><br>• ’833 Patent Claim 8 | |

| Section | Term | Construction |
|---|---|---|
| AGREED | "serially multiplexing first control signals and data signals, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals"<br><br>• '833 Patent Claims 1, 8 | "first control signals and data signals are mapped with a sequence in which one is directly after the other, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals" |
| | "mapping the multiplexed signals to"<br><br>• '833 Patent Claim 1, 8 | "after placing the first control signals and the data signals [in step (a)], mapping the multiplexed signals to" |
| | "mapping ACK/NACK control signals to"<br><br>• '833 Patent Claim 1, 8 | "after mapping the multiplexed signals [in step (b)], mapping ACK/NACK control signals to" |
| | "transport format"<br><br>• '284 Patent Claim 1, 14 | "transport format, transport block size, payload size, or modulation and coding scheme" |
| | "based on a received uplink signal"<br><br>• '774 Patent Claim 6 | no construction necessary |

**So ORDERED and SIGNED this 7th day of April, 2020.**

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF TEXAS

MARSHALL DIVISION

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, | )( | |
| LLC, ET AL., | )( | CIVIL ACTION NO. |
| PLAINTIFFS, | )( | 2:19-CV-066-JRG |
| VS. | )( | MARSHALL, TEXAS |
| | )( | |
| APPLE INC., | )( | JULY 27, 2020 |
| DEFENDANTS. | )( | 9:04 A.M. |

PRETRIAL HEARING

BEFORE THE HONORABLE JUDGE RODNEY GILSTRAP

UNITED STATES CHIEF DISTRICT JUDGE

FOR THE PLAINTIFFS: (See Attorney Attendance Sheet docketed in minutes of this hearing.)

FOR THE DEFENDANT: (See Attorney Attendance Sheet docketed in minutes of this hearing.)

COURT REPORTER: Shelly Holmes, CSR, TCRR
Official Reporter
United States District Court
Eastern District of Texas
Marshall Division
100 E. Houston Street
Marshall, Texas 75670
(903) 923-7464

(Proceedings recorded by mechanical stenography, transcript produced on a CAT system.)

03:03:05 the heart, the focus of the claims, as Dr. Madisetti
03:03:08 himself said, is the equation. The equations are abstract
03:03:13 concepts, non-patentable, and there's no inventive concepts
03:03:17 here to save the claims.
03:03:18 THE COURT: All right.
03:03:19 MR. SELWYN: Thank you, Your Honor.
03:03:19 THE COURT: Thank you.
03:03:20 Well, with regard to Apple's motion for summary
03:03:27 judgment under Section 101 of the Patent Act -- this is
03:03:31 Document 164 -- that motion is denied. The Court is
03:03:37 persuaded that the claims are not abstract. They're not
03:03:45 directed merely to an equation.
03:03:48 The Court's persuaded that they're directed to
03:03:51 applying the equation in a way that offers a technological
03:03:55 improvement.
03:03:55 And somewhat perplexingly, at least to the
03:04:01 briefing, Apple's argument relies on what was known or
03:04:04 already decided at the 3GPP.
03:04:08 Also, with regard to Plaintiffs' motion for
03:04:16 summary judgment of no derivation as to the '284 and
03:04:19 the '154 patents and no obviousness as to the '154 patent,
03:04:26 that motion is denied, as well.
03:04:30 This doesn't impact any outstanding motion to
03:04:34 strike with regard to the particular expert that may still
03:04:36 be live before the Court. But I don't see a basis upon

CERTIFICATION

I HEREBY CERTIFY that the foregoing is a true and correct transcript from the stenographic notes of the proceedings in the above-entitled matter to the best of my ability.

/S/ Shelly Holmes 7/29/2020
SHELLY HOLMES, CSR, TCRR Date
OFFICIAL REPORTER
State of Texas No.: 7804
Expiration Date: 12/31/2020

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, | )( | |
| LLC, ET AL., | )( | CIVIL ACTION NO. |
| PLAINTIFFS, | )( | 2:19-CV-066-JRG |
| VS. | )( | MARSHALL, TEXAS |
| | )( | |
| APPLE INC., | )( | JULY 28, 2020 |
| DEFENDANTS. | )( | 9:09 A.M. |

SEALED PORTION NOS. 1 AND 2 OF PRETRIAL HEARING
BEFORE THE HONORABLE JUDGE RODNEY GILSTRAP
UNITED STATES CHIEF DISTRICT JUDGE

FOR THE PLAINTIFFS: (See Attorney Attendance Sheet docketed in minutes of this hearing.)

FOR THE DEFENDANT: (See Attorney Attendance Sheet docketed in minutes of this hearing.)

COURT REPORTER: Shelly Holmes, CSR, TCRR
Official Reporter
United States District Court
Eastern District of Texas
Marshall Division
100 E. Houston Street
Marshall, Texas 75670
(903) 923-7464

(Proceedings recorded by mechanical stenography, transcript produced on a CAT system.)

of the case and to keep the focus elsewhere.

So as Mr. Kennedy conceded, at the time of settlement, [redacted]

So, methodologically, he's all over the place. He's not accounting for the relevant facts, and it would become Apple's job to try to fix that, and that's where we get into the prejudice, Your Honor, because he hasn't even attempted to do it. And he's not going to account for the relevant facts, and the Federal Circuit has been clear that you may in some circumstances use a settlement agreement, but it has to be explained properly by the expert. It has to be put into proper context. And Mr. Kennedy just has not tried to do that here.

THE COURT: All right. Thank you.

MR. SYRETT: Thank you.

THE COURT: Mr. Sheasby, if you'll approach, I'll hand you back your copy of this report on Mr. Kennedy.

Ms. Lockhart.

All right. With regard to Apple's motion to preclude expert testimony and opinions of David Kennedy, the 171 motion, with regard to the three theories that were

challenged, the infrastructure cost approach, the carrier scarcity approach, and the survey approach, those are denied as I've earlier announced.

With regard to what has been classified as, quote, other issues, particularly the bargaining share analysis, the method claims, the Qualcomm agreement, and the Dwyer opinion, I'm going to deny those, as well.

I think those can be addressed by cross-examination. I don't see that the deficiencies pointed out by the Defendant rise to the level of absolutely excluding these opinions.

All right. Next damages motion.

And we remain under seal. Unless there's some reason to maintain it, I'm going to order the courtroom unsealed at this point.

_______________________________________________________

(Sealed Portion No. 2, excerpted amount ordered sealed by the Court.)

MR. SHEASBY: $25 million.

CERTIFICATION

I HEREBY CERTIFY that the foregoing is a true and correct transcript from the stenographic notes of the proceedings in the above-entitled matter to the best of my ability.

/S/ Shelly Holmes 7/28/2020
SHELLY HOLMES, CSR, TCRR Date
OFFICIAL REPORTER
State of Texas No.: 7804
Expiration Date: 12/31/2020

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| **OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED,** | § | |
| ***Plaintiffs,*** | § | **CIVIL ACTION NO. 2:19-CV-00066-JRG** |
| **v.** | § | |
| **APPLE INC.,** | § | |
| ***Defendant.*** | § | |

**ORDER ON PRETRIAL MOTIONS AND MOTIONS *IN LIMINE***

The Court held a Pretrial Conference in the above-captioned case on July 27–29, 2020, regarding pretrial motions and motions *in limine* ("MILs") filed by Plaintiffs Optis Wireless Technology, LLC; Optis Cellular Technology, LLC; PanOptis Patent Management, LLC; Unwired Planet, LLC; and Unwired Planet International Limited (collectively, "Plaintiffs" or "Optis") and Defendant Apple Inc. ("Apple") (collectively, the "Parties"). This Order summarizes and memorializes the Court's rulings and reasons therefor on the aforementioned motions as announced into the record, including additional instructions that were given to the Parties. This Order in no way limits or constrains the Court's ruling as announced into the record from the bench. Accordingly, it is hereby **ORDERED** as follows:

## PRETRIAL MOTIONS

### I. Defendant Apple Inc's Motion for Summary Judgment of Patent Exhaustion and License of U.S. Patent Number 8,005,154 and 9,001,774 (Dkt. No. 232)

This motion is **DENIED**. (Dkt. No. 436 at 28:23–29:15; 30:4–12.)

### II. Plaintiffs' Motion for Summary Judgment on Apple's Affirmative Defense of Patent Exhaustion and/or License (Dkt. No. 161)

This motion is **DENIED**. (Dkt. No. 436 at 29:16–30:12.)

### III. Plaintiffs' Request for Judicial Notice Regarding Motion for Summary Judgment on Apple's Affirmative Defense of Patent Exhaustion and/or License (Dkt. No. 162)

This request is **GRANTED**. (Dkt. No. 436 at 25:1–3.)

### IV. Plaintiffs' Motion for Summary Judgment that Plaintiffs Did Not Breach Their FRAND Obligations (Dkt. No. 165)

This Motion is **DENIED**. (Dkt. No. 435 at 56:1–3.)

### V. Apple Inc.'s Motion to Dismiss Count VIII for Lack of Subject Matter Jurisdiction (Dkt. No. 169)

This Motion is **DENIED**. (Dkt. No. 435 at 55:17–19.)

### VI. Apple Inc.'s Motion to Strike Plaintiff's Reply to Apple Inc.'s Defenses (Dkt. No. 138)

This Motion is **GRANTED**. (Dkt. No. 435 at 55:12–14.) Plaintiff's new allegations in its Answer and Reply to Apple's Defenses and Counterclaims (Dkt. No. 131) are **STRICKEN**. (*Id.* at 55:12–16.)

### VII. Plaintiffs' Motion for Summary Judgment of No Derivation for U.S. Patent No. 8,385,284 and 8,005,154 and No Obviousness for 8,005,154 (Dkt. No. 167)

This Motion is **DENIED**. (Dkt. No. 435 at 98:19–22.)

### VIII. Apple Inc.'s Motion for Summary Judgment of Invalidity of Asserted Claims of U.S. Patent No. 8,019,332 Under 35 U.S.C. § 101 (Dkt. No. 164)

This Motion is **DENIED**. (Dkt. No. 435 at 98:8–12.)

### IX. Plaintiffs' Motion to Exclude and Strike Portions of Mr. Lanning's Opening Reports Regarding Invalidity of U.S. Patent Nos. 8,019,332 and 8,411,557 (Dkt. No. 173)

This Motion is **DENIED** with regard to opinions regarding Apple's intent. (Dkt. No. 437 at 79:5–7.) This Motion is **DENIED** as to Mr. Lanning's opinions regarding previously disclosed non-infringing alternatives and those regarding alleged non-infringing alternatives. (Dkt. No. 435 at 157:1–6.) The Motion is **DENIED** as to opinions relating to unelected background prior art. (Dkt. No. 435 at 161:2–15.)

This Motion is **GRANTED-IN-PART**, and **DENIED-IN-PART** with regards to Mr. Lanning's discussion of prosecution conduct. (Dkt. No. 435 at 167:2–5.) This Motion is **DENIED** with regard to testimony as to what the PTO did or did not have during prosecution. (*Id.* at 167:2–3.) This Motion is **GRANTED** to the extent the testimony seeks to characterize the materials the PTO had during prosecution, including references to why the PTO had the materials it had, when the PTO had said materials, and implications as to fault of the availability of those materials. (*Id.* at 167:3–5.)

This Motion is **DENIED** with regard to secondary considerations of nonobviousness. (Dkt. No. 435 at 174:22–175:1; 177:1–4) and **DENIED** with regard to hearsay from Apple engineers. (Dkt. No. 435 at 123:13–19; 124:8–16.)

This Motion is **DENIED AS MOOT** as to the remaining sections. (Dkt. No. 437 at 117:1–15.)

### X. Plaintiffs' Motion to Exclude and Strike Portions of Dr. Wells's Rebuttal Report Regarding Non-Infringement of U.S. Patent No. 9,001,774 (Dkt. No. 183)

This Motion is **DENIED** as to Mr. Wells's apportionment analysis in paragraph 320 of his report. (Dkt. No. 437 at 110:2–5.) This Motion is **DENIED AS MOOT** as to the remaining sections. (Dkt. No. 437 at 109:1–8; 117:1-15.)

### XI. Plaintiffs' Motion to Exclude and Strike Portions of Dr. Wells's Rebuttal Expert Report Regarding Non-Infringement of U.S. Patent No. 8,102,833 (Dkt. No. 184)

This Motion is **DENIED** with respect to the evaluation of comparable licenses. (Dkt. No. 437 at 112:15–17.) This Motion is **GRANTED** with regard to evaluation of the value of the '833 Patent, and accordingly, "thousands of" on line two of paragraph 378 is **STRICKEN**. (*Id.* at 113:21–25.) This Motion is **GRANTED** with regards to the apportionment analysis; accordingly, the second sentence of paragraph 377 is **STRICKEN**. (*Id.* at 115:20–22.) The last sentence of paragraph 377 is **STRICKEN-AS-AGREED**. (*Id.* at 115: 22–24.)

This Motion is **DENIED** with regard to hearsay from Apple engineers. (Dkt. No. 435 at 124:8–16.)

This Motion is **DENIED AS MOOT** as to the remaining sections. (Dkt. No. 437 at 117:1–15.)

### XII. Plaintiffs' Motion to Exclude and Strike Portions of Dr. Buehrer's Opening Report Regarding Invalidity of U.S. Patent No. 8,005,154 (Dkt. No. 179)

This Motion is **DENIED-AS-MOOT**. (Dkt. No. 437 at 45:2–5.)

### XIII. Defendant Apple Inc.'s Motion for Summary Judgment on Plaintiffs' Claims of Pre-Suit Damages, Indirect Infringement, and Willful Infringement (Dkt. No. 182)

This Motion is **DENIED**. (Dkt. No. 437 at 43:15–16; 44:10–11.)

### XIV. Plaintiffs' Motion to Strike Portions of the Opening Expert Report of Dr. Jonathan Wells, Ph.D. Regarding Invalidity of U.S. Patent No. 8,102,833, Invalidity of U.S. Patent No. 9,001,774, and 3GPP Processes (Dkt. No. 166)

This Motion is **DENIED** with respect to opinions relating to unelected prior art (Dkt. No. 437 at 47:10–11) and **DENIED** as to opinions relying on unspecified knowledge of a POSITA. (*Id.* at 47:10–11.) This Motion is **DENIED** with respect to opinions based on an 'if infringed, then invalid' contingent analysis (*Id.* at 51:8–9); **DENIED** with respect to opinions regarding previously undisclosed non-infringing alternatives (*Id.* at 56:19); **DENIED** with respect to

opinions regarding alleged non-infringing alternatives (*Id.* at 63:25–64:2); and **DENIED** with respect to hearsay from Apple engineers. (*Id.* at 64:6–10.) This Motion is also **DENIED** with respect to new facts, arguments, or theories not disclosed during fact discovery. (Dkt. No. 437 at 67:15.) The Motion is **DENIED** with respect to opinions regarding the state of mind of Panasonic, LG, and 3GPP, as well as **DENIED** with regards to commentary on the prior patent owners with respect to Apple and its suppliers. (*Id.* at 68:10–11.)

This Motion is **DENIED AS MOOT** as to the remaining sections. (Dkt. No. 437 at 117:1–15.)

### XV. Defendant Apple Inc.'s Motion to Preclude Plaintiffs' Experts from Offering Legal Conclusions and/or Opinions as to State of Mind (Dkt. No. 163)

This Motion is **DENIED** with respect to the legal effect of ETSI disclosures. (Dkt. No. 437 at 71:1–2.) Further, with respect to opinions about the legal effect of the confidentiality agreement, this Motion is **DENIED AS MOOT** in light of the Court's ruling that the non-disclosure agreement is applicable to communications during its effective period. (*Id.* at 71:22–24.) The Motion is **DENIED** with regard to Apple's state of mind. (*Id.* at 79:5–13, 19–21.)

The Motion is **CARRIED** with regard to grounds against Mr. Kennedy, Mr. Borghetti, and Ms. Dwyer. (*Id.* at 81:6–7; 82:12–15.)

### XVI. Plaintiffs' Motion to Strike Portions of Mr. Lanning's Rebuttal Expert Report Regarding Non-Infringement of U.S. Patent Nos. 8,019,332, 8,411,557, and Related Issues (Dkt. No. 172)

This Motion is **GRANTED-IN-PART** with regard to the apportionment analysis. Accordingly, "the '557 patent is only one of tens of thousands of patents declared essential to the 3GPP TS 36.211, 36.213, 36.300, 36.321, and 36.331 specifications to which Dr. Madisetti cites in his analysis" is **STRICKEN** from paragraph 376. (Dkt. No. 437 at 99:20–100:2.) Paragraph

377 is also **STRICKEN**. (*Id.* at 100:3–5.) The first three sentences of paragraph 375 and the following word "And" are **STRICKEN**. (*Id.* at 100:9–20.) Also **STRICKEN** is "in the sense that it overstates the actual percentage value for several reasons" from paragraph 299. (*Id.* at 102:12–18.) The Motion as to the apportionment analysis is **DENIED-IN-PART** with regard to paragraph 298. (*Id.* at 102:11–12.)

The remainder of this Motion is **DENIED AS MOOT**. (Dkt. No. 437 at 102:25–103:5; 117:1–15.)

### XVII. Motion to Exclude and Strike Portions of Dr. Buehrer's Rebuttal Report on the '284 Patent (Dkt. No. 176)

This Motion is **GRANTED** as regards testimony connecting timing of ETSI disclosures and essentiality; accordingly, the fourth sentence of paragraph 336 is **STRICKEN**. (Dkt. No. 435 at 139:25–140:7.)

This Motion is **DENIED** with regard to opinions regarding notice and the essentiality rate of declared patents (Dkt. No. 437 at 10:24–25.) The Motion is **DENIED** with regard to any opinion on whether pre-suit letters constitute notices of infringement. (*Id.* at 18:12–13.)

This Motion is **DENIED** with regard to improper expert testimony from Apple engineers. (Dkt. No. 435 at 123:13–19; 124:8–16.)

As regards apportionment analysis, this Motion is **GRANTED-BY-AGREEMENT** as to the first, second, and fifth sentences of paragraph 381, and such sentences are **STRICKEN**. (Dkt. No. 437 at 107:24–108:3.) This Motion is **GRANTED** as to the second sentence of paragraph 382. (*Id.* at 108:12–13.) The Motion is **WITHDRAWN** as to paragraph 383. (*Id.* at 108:14–16.)

This Motion is **DENIED AS MOOT** as to the remaining sections. (Dkt. No. 437 at 106:8–13; 107:22–23; 108:17–19; 117:1–15.)

**XVIII. Defendant Apple Inc.'s Motion for Argument Preclusion at Trial Based on Plaintiffs' Litigation Conduct (Dkt. No. 230)**

This Motion is **DENIED**. (Dkt. No. 437 at 144:12–15.)

**XIX. Defendant Apple Inc.'s Motion to Preclude Expert Testimony and Opinions of Johanna Dwyer (Dkt. No. 175)**

This Motion is **GRANTED** with regard to opinions that Plaintiffs were reasonable and met their FRAND obligations; accordingly Ms. Dwyer's opinions on FRAND are **STRICKEN**. (Dkt. No. 437 at 157:19–21; 158:5–9; 158:25–159:3; 161:11–13.) This Motion is **DENIED** with regard to reliance on claim charts. (*Id.* at 157:25–158:2.) This Motion is **DENIED** with regard to IPR opinions. (*Id.* at 158:3–4.)

**XX. Defendant Apple Inc.'s Motion to Preclude Expert Testimony and Opinions of Plaintiffs' Damages Expert David Kennedy (Dkt. No. 171)**

This Motion is **DENIED**. (Dkt. No. 438 at 27:23–28:7.)

**XXI. Defendant Apple Inc.'s Motion to Preclude Expert Testimony and Opinions of Rebecca Reed-Arthurs (Dkt. No. 174)**

This Motion is **DENIED**. (Dkt. No. 437 at 177:4–7.)

**XXII. Plaintiffs' Motion to Strike Opinions of Dr. Ray Perryman (Dkt. No. 168)**

This Motion is **DENIED**. (Dkt. No. 437 at 177:14–18.)

## MOTIONS *IN LIMINE*

**I. Plaintiffs' Motions *in Limine* (Dkt. No. 191)**

Plaintiffs' MIL No. 1: Apple should be precluded from offering lay witness infringement opinions.

This motion *in limine* is **GRANTED**. (Dkt. No. 437 at 195:3–10.)

Plaintiffs' MIL No. 2: Apple should be precluded from offering the testimony of Christian Faber.

This motion *in limine* is **GRANTED-BY-AGREEMENT**. (Dkt. No. 437 at 205:13–15.)

Plaintiffs' MIL No. 3: Apple should be precluded from presenting fact testimony beyond what was provided by Rule 30(b)(6) testimony.

This motion *in limine* is **WITHDRAWN**. (Dkt. No. 437 at 207:11.)

Plaintiffs' MIL No. 4: Apple should be precluded from offering evidence of foreign patent prosecution history.

This motion *in limine* is **GRANTED**. (Dkt. No. 437 at 208:11–12.)

Plaintiffs' MIL No. 5: Apple should be precluded from offering evidence on alleged inventor misconduct before the PTO.

This motion *in limine* is **GRANTED-BY-AGREEMENT**. (Dkt. No. 437 at 208:19.) The Parties are not to use any terms that would suggest misconduct. (*Id.* at 208:14–19.)

Plaintiffs' MIL No. 6: Apple should be precluded from referencing withdrawn patents.

This motion *in limine* is **GRANTED-BY-AGREEMENT**. (Dkt. No. 437 at 208:20–21.)

Plaintiffs' MIL No. 7: Apple should be precluded from presenting argument or evidence relating to third party patents.

This motion *in limine* is **WITHDRAWN**. (Dkt. No. 437 at 208:22; 183:9–10.)

Plaintiffs' MIL No. 8: Apple should be precluded from making any disparaging remarks about the value and propriety of patents acquired from others.

This motion *in limine* is **GRANTED**. (Dkt. No. 437 at 209:24–210:1.)

Plaintiffs' MIL No. 9: Apple should be precluded from making allegations that Qualcomm's licensing practices are not FRAND or are anti-competitive.

This motion *in limine* is **WITHDRAWN**. (Dkt. No. 437 at 210:2–3; 183:9–10.)

Plaintiffs' MIL No. 10: Apple should be precluded from offering testimony, evidence, or argument as to technical proposals, purporting to show that the patents-in-suit are not essential or not infringed because the patentee was not the author of the technology proposal adopted as the standard.

This motion *in limine* is **DENIED**. (Dkt. No. 437 at 213:11–13.)

Plaintiffs' MIL No. 11: Apple should be precluded from making remarks about the quality of the PTO and its examiners.

This motion *in limine* is **GRANTED-BY-AGREEMENT**. (Dkt. No. 437 at 213:14–17.)

Plaintiffs' MIL No. 12: Apple should be precluded from making pejorative remarks about Optis's corporate structure and acquisition by Hilco.

This motion *in limine* is **GRANTED-AS-STATED**. (Dkt. No. 437 at 215:11-15.) The motion *in limine* is **DENIED-IN-PART** with regard to remarks about the ordinary business structure of the parties. (*Id.* at 215:16–18.)

Plaintiffs' MIL No. 13: Apple should be precluded from arguing or introducing evidence as to practicing the prior art, or from comparing the accused products to anything other than the construed claims.

This motion *in limine* is **GRANTED-AS-AGREED**. (Dkt. No. 437 at 218:11–13.) Defendant is precluded from arguing that it does not infringe because it does not practice the prior art. (*Id.* at 217:14–15; 218:10; 218:11–14.) Defendant may argue invalidity under Plaintiffs' infringement theory. (*Id.* at 217:16–19; 217:25–218:3; 218:10; 218:11–14.)

Plaintiffs' MIL No. 14: Apple should be precluded from alleging that the predecessors of these patents (Samsung, Panasonic, LG) did not assert the patents-in-suit against Apple.

This motion *in limine* is **GRANTED**. (Dkt. No. 437 at 204:4–16.)

Plaintiffs' MIL No. 15: Apple should be precluded from discussing timing of the disclosure of standard essential patents before the jury.

This motion *in limine* is **DENIED-AS-MOOT**. (Dkt. No. 437 at 219:8–9.)

Plaintiffs' MIL No. 16: Apple should be precluded from alleging that it respects intellectual property.

This motion *in limine* is **WITHDRAWN**. (Dkt. No. 437 at 219:10; 183:9–10.)

Plaintiffs' MIL No. 17: Apple should be precluded from presenting evidence to the jury of the parties' non-disclosure agreement.

This motion *in limine* is **WITHDRAWN**. (Dkt. No. 437 at 219:18; 219:15–16.)

Plaintiffs' MIL No. 18: Apple should be precluded from making reference to the absence of inventors at trial.

This motion *in limine* is **GRANTED.** (Dkt. No. 437 at 220:20–21.)

## II. Defendant's Motions *in Limine* (Dkt. No. 192)

Defendant's MIL No. 1: Plaintiffs should be precluded from making reference evidence, arguments, verdicts, judgments, or orders from other litigations.

This motion *in limine* is **GRANTED**. (Dkt. No. 437 at 224:25–225:4.)

Defendant's MIL No. 2: Plaintiffs should be precluded from referring to the parties' pre-suit licensing negotiations and correspondence under FRE 408 and the parties' confidentiality agreement.

This motion *in limine* is **DENIED**. (Dkt. No. 437 at 230:1–231:15.)

Defendant's MIL No. 3: Plaintiffs should be precluded from offering opinions of experts who do not testify at trial or are not qualified as experts.

This motion *in limine* is **DENIED**. (Dkt. No. 437 at 233:12–13.)

Defendant's MIL No. 4: Plaintiffs should be precluded from referring to the expert report drafting process and communication between experts and trial teams.

This motion *in limine* is **DENIED**. (Dkt. No. 437 at 235:7–8.)

Defendant's MIL No. 5: Plaintiffs should be precluded from offering evidence or arguments to the jury regarding French law.

This motion *in limine* is **GRANTED-AS-AGREED**. (Dkt. No. 437 at 235:22–25.)

Defendant's MIL No. 6: Plaintiffs should be precluded from offering infringement arguments based on comparing accused products to embodiments in the specification.

This motion *in limine* is **DENIED**. (Dkt. No. 437 at 237:14–16.)

Defendant's MIL No. 7: Plaintiffs should be precluded from offering evidence or argument on undisclosed doctrine of equivalents arguments.

This motion *in limine* is **DENIED**. (Dkt. No. 437 at 238:9.)

Defendant's MIL No. 8: Plaintiffs should be precluded from offering comparisons of the burden of proof standards to other areas of the law.

This motion *in limine* is **GRANTED-BY-AGREEMENT**. (Dkt. No. 437 at 238:18–19; 239:22–23.)

Defendant's MIL No. 9: Plaintiffs should be precluded from offering improper proof of conception evidence.

This motion *in limine* is **DENIED**, and will be addressed with exhibit disputes. (Dkt. No. 437 at 240:8–9, 12–13.)

Defendant's MIL No. 10: Plaintiffs should be precluded from offering evidence regarding Apple's foreign operations.

This motion *in limine* is **GRANTED**. (Dkt. No. 437 at 241:23–24.)

Defendant's MIL No. 11: Plaintiffs should be precluded from offering evidence regarding Apple's overall financial numbers.

This motion *in limine* is **GRANTED** to preclude references to total corporate earning, market capitalization, stock price, cash reserves, ability to pay or overall corporate indications of wealth in regard to either party. (Dkt. No. 437 at 243:23–244:4.)

Defendant's MIL No. 12: Plaintiffs should be precluded from offering evidence or argument regarding witness compensation unrelated to this case.

This motion *in limine* is **GRANTED**. (Dkt. No. 437 at 246:15–19.)

Defendant's MIL No. 13: Plaintiffs should be precluded from offering evidence regarding Steve Jobs, political positions taken by Apple or its leadership, media reports unrelated to this litigation, and/or media speculation about Apple.

This motion *in limine* is **GRANTED**, and references to matters unrelated to the litigation are precluded. (Dkt. No. 437 at 248:20–23.)

Defendant's MIL No. 14: Plaintiffs should be precluded from offering arguing that publishing patent applications or declaring patent applications to ETSI constitutes notice of alleged infringement.

This motion *in limine* is **AGREED** in light of the Court's other pretrial rulings. (Dkt. No. 437 at 187:24–188:10.)

## DISPUTES AS TO REMAINING PRETRIAL ISSUES

The Court **ORDERED** that FRAND issues will be tried to the bench. (Dkt. No. 435 at 56:25–57:4.)

**So ORDERED and SIGNED this 3rd day of August, 2020.**

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, PLAINTIFFS, | )( | CIVIL ACTION NO. 2:19-CV-66-JRG |
| VS. | )( | |
| APPLE INC., DEFENDANTS. | )( | MARSHALL, TEXAS AUGUST 6, 2020 1:03 P.M. |

TRANSCRIPT OF JURY TRIAL

AFTERNOON SESSION

BEFORE THE HONORABLE JUDGE RODNEY GILSTRAP

UNITED STATES CHIEF DISTRICT JUDGE

APPEARANCES:

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Eastern District of Texas
Marshall Division
100 E. Houston
Marshall, Texas 75670
(903) 923-7464

(Proceedings recorded by mechanical stenography, transcript produced on a CAT system.)

03:31:18 version, they came up with this table 8.6.1-1.
03:31:23 Q. Does this '284 patent being asserted by the plaintiffs
03:31:28 in this case cover this table?
03:31:31 A. No, it does not.
03:31:36 MR. MUELLER: Now, if we could go back to
03:31:40 DDX-7.18.
03:31:41 Q. (By Mr. Mueller) What do we see here, sir?
03:31:42 A. So here are two of the -- two of the asserted claims
03:31:48 from the '284 patent.
03:31:50 Q. And I'd like to focus your attention on the bottom of
03:31:54 these two claims, the very last piece. Do you see that,
03:31:57 sir?
03:31:57 A. Yes, I do.
03:31:57 Q. Could you read that to us?
03:31:59 A. Sure. It says: Wherein the first subset of the values
03:32:03 contains more values than the second subset of the values.
03:32:06 Q. And was this a requirement that was added to the patent
03:32:10 during the back and forth at the Patent Office?
03:32:12 MR. SHEASBY: Your Honor, I object.
03:32:14 A. Yes, it was.
03:32:15 MR. SHEASBY: Relevance, and the answer should be
03:32:17 stricken.
03:32:18 THE COURT: I don't see any relevance. I'll
03:32:24 sustain the objection.
03:32:25 MR. MUELLER: Thank you, Your Honor. I may bring

03:32:27 that up again and ask Your Honor's permission in the validity context, but I can wait until then.

03:32:33 THE COURT: Well, if you can establish some relevance, then you can certainly raise it then. Let's move along.

03:32:39 MR. MUELLER: Thank you, Your Honor.

03:32:40 Q. (By Mr. Mueller) So, we're in the first subset of the values contains more values than the second subset of the values. Do you see that, sir?

03:32:47 A. Yes, I do.

03:32:47 Q. Now --

03:32:47 MR. MUELLER: Your Honor, may we ask permission -- may I ask permission now for Dr. Buehrer to come up to the placard that I'm going to put on this easel, and I'll move it over here and Dr. Buehrer can put a face shield on.

03:32:57 THE COURT: We'll do it just like we did with Mr. Summersgill earlier.

03:33:01 MR. MUELLER: Thank you, Your Honor.

03:33:25 THE COURT: Just a minute. We need a handheld microphone for the witness, please.

03:33:32 And then you need to examine him from the other side of the demonstrative, Mr. Mueller.

03:33:36 MR. MUELLER: Thank you -- thank you, Your Honor.

03:34:12 May I proceed, Your Honor?

03:34:14 THE COURT: You may proceed.

MR. MUELLER: Thank you, Your Honor.
Q. (By Mr. Mueller) Dr. Buehrer, in your role as an expert in this case, have you seen any evidence that Samsung, Panasonic, or LG ever contacted Apple about the patents in this case?
A. No, I have not.
Q. Now, Mr. Sheasby asked you about the tables in the patent, right, sir?
A. Correct.
Q. Those tables, were they in the original patent application or not in the original patent application?
A. They were in the original application.
Q. And so when Samsung -- I'm sorry, Panasonic first applied for the '284 patent, were those tables in the original patent application or not?
A. Yes, they were.
MR. MUELLER: Your Honor, at this point I would request leave to inquire into the prosecution history, which goes to the issue of why the claims that are being asserted don't cover those tables.
THE COURT: What's the Plaintiffs' response?
MR. SHEASBY: Your Honor, first off, this is outside of the scope of -- of cross-examination. I never referenced whatsoever to these tables. The tables were in the patents that were discussed in the direct examination.

04:43:45 THE COURT: Rule 40 -- excuse me. Rule 611 doesn't talk about the scope of cross. It talks about the scope of direct.

04:43:52 MR. SHEASBY: Your Honor, then it's the same objection. I believe what he's trying to do is discuss the claim history of the patents, which is a subject for this Court. It's not a subject for the jury.

04:44:01 MR. MUELLER: That's incorrect, Your Honor. And the suggestion to the jury was explicitly that they consider Dr. Buehrer to have less credibility. That was the explicit argument by Mr. Sheasby, because the claims don't cover the tables.

04:44:13 The reason they don't cover the tables is because of how the claims were amended during the prosecution history, and that's what I'd like to inquire into.

04:44:22 MR. SHEASBY: Your Honor, that is an absolutely inappropriate use of the prosecution history. Counsel just tried to get in evidence through his argument that --

04:44:28 THE COURT: All right. I've heard enough, gentlemen. I'm going to sustain this objection. I don't think the door has been completely opened here.

04:44:38 Q. (By Mr. Mueller) Dr. Buehrer, just focusing on the claims themselves --

04:44:43 MR. MUELLER: And, Your Honor, can I put the placard up?

04:56:42 morning.

04:56:42 We stand in recess for the evening.

04:56:45 COURT SECURITY OFFICER: All rise.

04:56:46 (Recess.)

05:05:54

05:05:54 CERTIFICATION

I HEREBY CERTIFY that the foregoing is a true and correct transcript from the stenographic notes of the proceedings in the above-entitled matter to the best of my ability.

/S/ Shelly Holmes 8/6/2020
SHELLY HOLMES, CSR, TCRR Date
OFFICIAL REPORTER
State of Texas No.: 7804
Expiration Date: 12/31/2020

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, PLAINTIFFS, | )( | CIVIL ACTION NO. 2:19-CV-66-JRG |
| VS. | )( | MARSHALL, TEXAS AUGUST 7, 2020 |
| APPLE INC., DEFENDANTS. | )( | |

PARTIAL TRANSCRIPT OF JURY TRIAL

SEALED PORTIONS NOS. 17-19 - AFTERNOON SESSION

BEFORE THE HONORABLE JUDGE RODNEY GILSTRAP

UNITED STATES CHIEF DISTRICT JUDGE

APPEARANCES:

FOR THE PLAINTIFFS:

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COURT REPORTER: Ms. Shelly Holmes, CSR, TCRR
Official Court Reporter
United States District Court
Eastern District of Texas
Marshall Division
100 E. Houston
Marshall, Texas 75670
(903) 923-7464

(Proceedings recorded by mechanical stenography, transcript produced on a CAT system.)

A. His testimony was that the tables, Table 3 through 8 -- Tables 3 through 8 that are in the patent itself are irrelevant -- or are -- are not supported by the claim limitation language.

So you have to understand, you read the claim limitation language -- again, based upon the Court's construction for construed terms -- and you read the patent spec. He's saying that the patent spec itself does not support the claim language, which is the whole purpose of the written patent spec.

MR. MUELLER: Your Honor, I move to strike. The witness is instructing the witness -- the jury how to interpret the claims, and he's also doing so in an incorrect fashion.

The task for the jury is to apply the claims to the accused products. He's providing further instruction that's for Your Honor, not the witness.

THE COURT: Response?

MR. SHEASBY: Your Honor, a person of ordinary skill in the art must understand the non-construed elements of the claims. What Dr. Mahon is saying is that Dr. Buehrer's interpretation of the claims as a person of ordinary skill in the art is inconsistent with all eight tables in the patents.

That's not claim construction. That's him

criticizing what a person of ordinary skill in the art would understand based on the claims.

MR. MUELLER: And, again, Your Honor, Dr. Buehrer applied the claims to the products. What Dr. Mahon is now doing is asking the jury to do claim construction and to do it in the wrong way.

MR. SHEASBY: Your Honor, this is not just an argument; this is not an objection.

THE COURT: All right. I'm going to overrule the objection. I don't believe the witness is asking the jury to do claim construction, and under no circumstances would that be appropriate, but I don't believe that's what's being called for.

MR. SHEASBY: Let's go back to the presentation.

Q. (By Mr. Sheasby) Did you confirm your understanding of how Apple's products work based on analyzing the source code?

A. Yes, I did.

Q. What is the conclusion of your analysis?

A. Based upon my analysis, I conclude that the Apple source code for both the Qualcomm and Intel chipsets support my conclusion that the devices infringe the claim --

Q. And why --

A. -- Claim 6.

Officer to invite the public to return.

(END OF SEALED PORTION NO. 19.)

CERTIFICATION

I HEREBY CERTIFY that the foregoing is a true and correct transcript from the stenographic notes of the proceedings in the above-entitled matter to the best of my ability.

/S/ Shelly Holmes ________ 8/7/2020
SHELLY HOLMES, CSR, TCRR Date
OFFICIAL REPORTER
State of Texas No.: 7804
Expiration Date: 12/31/20

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

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| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, PLAINTIFFS, | )( | CIVIL ACTION NO. 2:19-CV-66-JRG |
| VS. | )( | |
| | )( | MARSHALL, TEXAS AUGUST 10, 2020 9:52 A.M. |
| APPLE INC., DEFENDANTS. | )( | |

TRANSCRIPT OF JURY TRIAL

ALL DAY

BEFORE THE HONORABLE JUDGE RODNEY GILSTRAP

UNITED STATES CHIEF DISTRICT JUDGE

APPEARANCES:

FOR THE PLAINTIFFS:

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United States District Court
Eastern District of Texas
Marshall Division
100 E. Houston
Marshall, Texas 75670
(903) 923-7464

(Proceedings recorded by mechanical stenography, transcript produced on a CAT system.)

objection raised in chambers regarding the instruction to bypass the validity question if a finding of non-infringement is entered.

THE COURT: All right. That's overruled.

Is there objection here from the Defendant?

MR. SELWYN: Yes. For the record, Your Honor Apple objects to Question 1 because it does not break out infringement by patent or by literal infringement and infringement under the Doctrine of Equivalents.

THE COURT: That's overruled.

I'll turn next to Page 5 where Question 2 to the jury is located.

Is there objection here from either party?

MS. GLASSER: No, Your Honor.

MR. SELWYN: No objection, Your Honor.

THE COURT: Turning then to Page 6 where Question 3 to the jury is located, is there objection here from either party?

MS. GLASSER: No, Your Honor.

MR. SELWYN: Your Honor, for the record, Apple objects to Question No. 3, essentially for the same reason as Question 1 -- that is, it does not break out willful infringement by patent or by literal infringement and infringement under the Doctrine of Equivalents.

THE COURT: That's overruled.

CERTIFICATION

I HEREBY CERTIFY that the foregoing is a true and correct transcript from the stenographic notes of the proceedings in the above-entitled matter to the best of my ability.

/S/ Shelly Holmes 8/10/2020
SHELLY HOLMES, CSR, TCRR Date
OFFICIAL REPORTER
State of Texas No.: 7804
Expiration Date: 12/31/20

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § | |
| *Plaintiffs*, | § | |
| v. | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| APPLE INC., | § | |
| *Defendant*. | § | |

## VERDICT FORM

In answering the following questions and completing this Verdict Form, you are to follow all the instructions I have given you in the Court's Final Jury Instructions. Your answers to each question must be unanimous. Some of the questions contain legal terms that are defined and explained in detail in the Final Jury Instructions. You should refer to and consider the Final Jury Instructions as you answer the questions in this Verdict Form.

As used herein, the following terms have the following meanings:

- "Optis" refers to collectively Optis Wireless Technology, LLC; Optis Cellular Technology, LLC; Unwired Planet, LLC; PanOptis Patent Management, LLC; and Unwired Planet International Limited
- "Apple" refers to Apple Inc.
- The "'332 Patent" refers to U.S. Patent No. 8,019,332
- The "'284 Patent" refers to U.S. Patent No. 8,385,284
- The "'557 Patent" refers to U.S. Patent No. 8,411,557
- The "'774 Patent" refers to U.S. Patent No. 9,001,774
- The "'833 Patent" refers to U.S. Patent No. 8,102,833.
- The "Asserted Claims" refers collectively to Claims 6 and 7 of the '332 Patent; Claims 1, 14, and 27 of the '284 Patent; Claims 1 and 10 of the '557 Patent; Claim 6 of the '774 Patent; and Claim 8 of the '833 Patent.

**<u>IT IS VERY IMPORANT THAT YOU FOLLOW THE INSTRUCTIONS PROVIDED IN THIS VERDICT FORM.</u>**

**<u>READ THEM CAREFULLY AND ENSURE YOUR VERDICT COMPLIES WITH THEM.</u>**

**QUESTION NO. 1:**

Did Optis prove by a preponderance of the evidence that Apple infringed **ANY** of the Asserted Claims?

Yes: Yes No: _______

If you answer this question "**NO**" do **NOT** answer any other questions, leave the remaining questions unanswered and go to the final page of the Jury Verdict form.

**QUESTION NO. 2:**

Did Apple prove by clear and convincing evidence that any of the following Asserted Claims are invalid?

**Answer "Yes" or "No" for each Asserted Claim listed below:**

| | |
|---|---|
| Claim 6 of the '332 Patent | No |
| Claim 7 of the '332 Patent | No |
| Claim 1 of the '284 Patent | No |
| Claim 14 of the '284 Patent | No |
| Claim 27 of the '284 Patent | No |
| Claim 1 of the '557 Patent | No |
| Claim 10 of the '557 Patent | No |
| Claim 6 of the '774 Patent | No |
| Claim 8 of the '833 Patent | No |

**<u>If you answered NO to Question No. 1 OR YES to ALL the Asserted Claims listed in Question No. 2, then DO NOT answer Question No. 3.</u>**

**<u>Answer Question No. 3 ONLY as to any Asserted Claim that you have found BOTH to be infringed and not invalid.</u>**

**<u>QUESTION NO. 3</u>**

Did Optis prove by a preponderance of the evidence that Apple willfully infringed **ANY** of the Asserted Claims that you found were infringed?

Yes: Yes No: _______

**If you answered NO to Question No. 1 OR YES to ALL the Asserted Claims listed in Question No. 2, then DO NOT answer Question No. 4a or 4b.**

**Answer Question No. 4a and 4b ONLY as to any Asserted Claim that you have found BOTH to be infringed and not invalid.**

## QUESTION NO. 4a:

What sum of money, if any, paid now in cash, has Optis proven by a preponderance of the evidence would compensate Optis for its damages resulting from infringement through the date of trial?

Answer in United States Dollars and Cents, if any:

$ 506,200,000

**QUESTION NO. 4b:**

Is the total amount you found in Question No. 4a a lump-sum for past and future sales or a royalty for past sales only?

Check **one** of the following:

**Lump-sum** ______

**—OR—**

**Royalty for past sales** ✓

**FINAL PAGE OF JURY VERDICT FORM**

You have now reached the end of the Verdict Form and should review it to ensure it accurately reflects your **unanimous** determinations. The Jury Foreperson should then sign and date the Verdict Form in the spaces below. Once this is done, notify the Court Security Officer that you have reached a verdict. The Jury Foreperson should keep the Verdict Form and bring it when the jury is brought back into the courtroom.

Signed this 11 day of August, 2020.

______________________
**Jury Foreperson**

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § | |
| *Plaintiffs*, | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| v. | § | |
| APPLE INC., | § | |
| *Defendant*. | § | |

**FINAL JUDGMENT**

A jury trial commenced in this case on August 3, 2020. On August 11, 2020, the jury returned a unanimous verdict (Dkt. No. 483) finding that Defendant Apple Inc. ("Apple") infringed one or more claims asserted by Plaintiffs Optis Wireless Technology, LLC; Optis Cellular Technology, LLC; PanOptis Patent Management, LLC; Unwired Planet, LLC; and Unwired Planet International Limited (collectively, "Optis"), such claims being 6 and 7 of U.S. Patent No. 8,019,332; claims 1, 14, and 27 of U.S. Patent No. 8,385,284; claims 1 and 10 of U.S. Patent No. 8,411,557; claim 6 of U.S. Patent No. 9,001,774; and claim 8 of U.S. Patent No. 8,102,833 (collectively, the "Asserted Claims"); that none of the Asserted Claims were invalid; that Apple's infringement had been willful; and that Optis should recover from Apple $ 506,200,000 as a reasonable royalty for such infringement.

The Court conducted a separate bench trial on August 11, 2020. The bench trial took up the issues of Count VIII as urged by Optis and also took up Apple's waiver defense. On

January 22, 2021, the Court issued Findings of Fact and Conclusions of Law, wherein the Court declined jurisdiction to decide whether Optis's offers were FRAND and held that Apple failed to show the asserted patents were unenforceable due to late disclosure to the standards-setting organization. (Dkt. No. 538.)

Optis has moved for entry of Final Judgment (Dkt. No. 541), which the Court now **GRANTS**.

Pursuant to Rule 58 of the Federal Rules of Civil Procedure and in accordance with the foregoing, the Court hereby **ORDERS** and **ENTERS JUDGMENT** as follows:

1. Apple has infringed one or more of the Asserted Claims;
2. The Asserted Claims are not invalid;
3. Apple's infringement was willful;
4. Optis is hereby awarded damages from and against Apple and shall accordingly have and recover from Apple the sum of $ 506,200,000.00 U.S. Dollars as a reasonable royalty for past sales through the date of trial;
5. Notwithstanding the jury's finding of willfulness, the Court having considered the totality of the circumstances together with the added material benefit of having presided throughout the jury trial and having seen both the same evidence and heard the same arguments as the jury, and mindful that enhancement is generally reserved for "egregious cases of culpable behavior,"[1] concludes that enhancement of the compensatory award herein is not warranted under 35 U.S.C. § 284 and consequently, the Court elects not to enhance the damages awarded herein;

[1] *Halo Electronics, Inc. v. Pulse Electronics, Inc.*, 136 S.Ct. 1923, 1934 (2016).

6. Pursuant to 35 U.S.C. § 284 and Supreme Court guidance that "prejudgment interest shall ordinarily be awarded absent some justification for withholding such an award,"[2] the Court awards pre-judgment interest applicable to all sums awarded herein, calculated at the 5-year U.S. Treasury Bill rate, compounded quarterly, from the date of infringement through the date of entry of this Judgment;[3] and

7. Pursuant to 28 U.S.C. § 1961, the Court awards post-judgment interest applicable to all sums awarded herein, at the statutory rate, from the date of entry of this Judgment until paid.

8. Pursuant to Federal Rule of Civil Procedure 54(d)(1) and 28 U.S.C. § 1920, Optis is the prevailing party, and as the prevailing party, Optis shall recover its costs from Apple. Optis is directed to file its proposed Bill of Costs.

All other requests for relief now pending before the Court and not specifically addressed herein are **DENIED**. The Clerk is directed to **CLOSE** the above-captioned case.

**So ORDERED and SIGNED this 25th day of February, 2021.**

Rodney Gilstrap

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

[2] *General Motors Corp. v. Devex Corp.*, 461 U.S. 648, 657 (1983).
[3] *See Nickson Indus., Inc. v. Rol Mfg. Co., Ltd.*, 847 F.2d 795, 800–801 (Fed. Cir. 1988).

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

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| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § | |
| *Plaintiffs*, | § | |
| v. | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| APPLE INC., | § | |
| *Defendant.* | § | |

**ORDER**

Before the Court is Defendant Apple Inc.'s ("Apple") Motion for New Trial On All Issues Due to Improper Preclusion of Evidence of Plaintiff's FRAND Obligation (the "Motion for New Trial"). (Dkt. No. 549.) In the Motion for New Trial, Apple requests a new trial under Federal Rule of Civil Procedure 59, arguing that the verdict is not fair, reasonable, and non-discriminatory ("FRAND") in accordance with the contractual terms surrounding the asserted standard essential patents ("SEPs"). Having considered the Motion for New Trial and for the reasons set forth herein, the Court is of the opinion that the Motion should be **GRANTED-IN-PART** and **DENIED-IN-PART**.

## I. Background

Plaintiffs Optis Wireless Technology, LLC; Optis Cellular Technology, LLC; PanOptis Patent Management, LLC; Unwired Planet, LLC; and Unwired Planet International Limited ("UPIL") (collectively, "Optis") filed the above-captioned case against Apple on February 25,

2019, asserting infringement of seven patents under the laws of the United States. (Dkt. No. 1 ¶ 1.) Prior to trial, two of the asserted patents were dropped by Optis. The Court conducted a jury trial with respect to the remaining five patents (U.S. Patent No. 8,019,332; U.S. Patent No. 8,385,284; U.S. Patent No. 8,411,557; U.S. Patent No. 9,001,774; and U.S. Patent No. 8,102,833 (collectively, the "Asserted Patents")) from August 3, 2020 through August 11, 2020. (Dkt. Nos. 460, 461, 466, 474, 482, 485, 486.) On August 11, 2020, the jury returned a verdict that Apple willfully infringed certain claims of the Asserted Patents. (Dkt. No. 483.) The jury awarded $ 506,200,000 as a reasonable royalty for such infringement. (*Id*.)

The Court entered Final Judgment on February 25, 2021, memorializing the jury's findings but electing not to enhance damages for willful infringement under 35 U.S.C. § 284. (Dkt. No. 544.)

**a. FRAND Litigation History**

Optis filed its First Amended Complaint on May 13, 2019. (Dkt. No. 26.) As a part thereof, Optis set forth that the Asserted Patents were SEPs, and alleged that the original assignees of the SEPs—including LG, Panasonic, Ericsson, and Samsung—offered licenses under FRAND terms consistent with their obligations as part of the European Telecommunications Standards Institute's ("ETSI") standard-setting organization, thereby forming a FRAND contract under French law.[1] (Dkt. No. 26 ¶¶ 136–141.) It is uncontested that the Asserted Patents are FRAND-encumbered SEPs. (*See* Dkt. No. 1 ¶ 22–36; Dkt. No. 360 at 17; Dkt. No. 549 at 5.) Optis alleged that Apple's bad faith conduct and holdout during pre-suit negotiations caused Apple to forfeit any FRAND defense. (Dkt. No. 360 at 5.)

[1] Optis argued that under French law, the existence of a FRAND contract triggered a duty by Apple to negotiate in good faith. (Dkt. No. 436 at 39:1–40:8; Dkt. No. 169 at 18.)

In Count VIII of its First Amended Complaint, Optis alleged that "[t]here is a dispute between the Plaintiffs and Apple concerning whether the Plaintiffs' history of offers to Apple for a global license to the Plaintiffs' essential patents complies with Plaintiffs' commitment to license their essential patents on FRAND terms and conditions pursuant to ETSI and ETSI's IPR Policy." (Dkt. No. 26 ¶ 143.) Count VIII sought "[a] declaration that Plaintiffs, in their history of negotiations with Apple in regard to a global license to the Plaintiffs' essential patents, have negotiated in good faith and otherwise complied with FRAND . . . ." (Dkt. No. 26 at 109.) Apple filed a Motion to Dismiss Count VIII of Plaintiffs' Complaint for Lack of Subject Matter Jurisdiction (Dkt. No. 16), which the Court granted-in-part and denied-in-part. (Dkt. No. 102.) The Court granted the motion and dismissed "any portion of Count VIII that seeks a declaration that Plaintiffs have complied with their obligations under foreign laws or as they relate to foreign patents, or that Apple may not raise a FRAND defense in a foreign jurisdiction." (*Id*. at 6.) The Court explained that "[l]ike claims for foreign patent infringement, claims asking the Court to pass upon foreign obligations under foreign laws related to foreign patents are best left to the courts of those foreign countries." (*Id*.) However, the motion was denied "as to Plaintiffs' request to declare the parties' rights with respect to U.S. patents or under U.S. state or federal law," which the Court declined to dismiss. (*Id*. at 9.) Nevertheless, the Court cautioned that "[w]hether or not Plaintiffs can prove these allegations in a manner sufficient to allow this Court to issue declaratory relief is a separate issue more appropriately analyzed under Rule 56 or at trial." (*Id*. at 8.) The Court further concluded that it "remains under 'a continuing obligation to examine the basis of [its] jurisdiction' and will not issue an advisory opinion if it becomes clear that there is no justiciable controversy before the Court." (*Id*. (citation omitted).)

**b. Pretrial Proceedings**

During pretrial proceedings before the Court, Optis deliberately elected to try what remained of its declaratory judgment claim to the bench, not the jury. Apple raised no objection to this decision. In the Joint Pretrial Order, the parties included "Plaintiffs' claim for a declaratory judgment" as an "issue[] to be tried to the Court in a bench trial immediately following the jury trial." (Dkt. No. 360 at 4.) The Court confirmed this fact with both sides on July 27, 2020 at the pretrial conference:

> THE COURT: Let me ask my question again. When you filed your most recently amended complaint, you inserted Count 8 that sought declaratory relief to find that Optis had complied with its FRAND obligation and that Apple had acted in bad faith and engaged in holdout. You sought a declaratory judgment to that effect. Did you then at the time of that amendment intend to try that issue to the jury or to the bench?
>
> [Optis's Counsel] MR. SHEASBY: No, Your Honor, it was our expectation that we try it to the bench.

(Dkt. No. 435 at 54:17–55:1; *see also* Dkt. No. 436 at 60:22–62:15 (Apple's counsel explaining that the issue of Plaintiff's FRAND compliance should be tried to the bench).)

Nonetheless, during trial Optis sought to separate the issue of its own FRAND compliance from the alleged misdeeds by Apple which Optis alleged caused Apple to forfeit its right to raise a FRAND defense. (Dkt. No. 435. at 55:5–62:23.) Under the guise of evidence relevant to willful infringement, Optis argued that evidence of Apple's bad faith and holdout during pre-suit negotiations should still be presented to the jury. (*Id*. at 67:12–68:6.) Specifically, despite the existence of a non-disclosure agreement covering licensing negotiations between the parties, Optis sought to introduce evidence from internal Apple documents showing that Apple's representations during negotiations were inconsistent with Apple's own licensing practices. (*See* Dkt. No. 436 at 36:2–23.) The Court rejected Optis's attempt to have it both ways—*i.e*., to use FRAND as both a sword (in the jury trial against Apple) and a shield (in a subsequent bench trial as to Optis's own

conduct). (Dkt. No. 435 at 55:5–62:23.) However, doing so necessarily meant that the jury was not presented with evidence regarding Optis's FRAND commitment or whether the requested reasonable royalty was FRAND-compliant. (*See* Dkt. No. 435 at 56:10–58:9.)

#### c. Bench Trial

Following the jury trial, on August 11, 2020, the Court conducted a bench trial regarding the issues of Optis's Count VIII and Apple's waiver defense. (Dkt. No. 487.) Having previously dismissed Optis's Count VIII as to foreign patents (Dkt. No. 102), the Court analyzed the evidence presented for any offers relating solely to U.S. patents. (Dkt. No. 538 at CL7.) The Court found that "Optis never made an offer specifically for or limited to its U.S. Patents," and accordingly declined to exercise jurisdiction over Count VIII. (*Id*. at CL4, CL7.) The Court further held that by failing to raise a counterclaim or affirmative defense, Apple waived its right to challenge the verdict as noncompliant with FRAND. (*Id*. at CL8.) Finally, the Court held that Apple failed to show the Asserted Patents were unenforceable due to late disclosure to the ETSI standard-setting organization. (Dkt. No. 538.)

## II. Applicable Law

A new trial may be granted on all or part of the issues on which there has been a trial by jury for "any reason for which a new trial has heretofore been granted in an action at law in federal court." Fed. R. Civ. P. 59(a). Notwithstanding the broad sweep of Rule 59, "courts do not grant new trials unless it is reasonably clear that prejudicial error has crept into the record or that substantial justice has not been done, and the burden of showing harmful error rests on the party seeking the new trial." *Metaswitch Networks Ltd. v. Genband US LLC*, No. 2:14-CV-00744, 2017 WL 3704760, at *2 (E.D. Tex. Aug. 28, 2017); *Erfindergemeinschaft UroPep GbR v. Eli Lilly & Co.*, 276 F. Supp. 3d 629, 643 (E.D. Tex. 2017). "A new trial may be granted, for example, if the

district court finds the verdict is against the weight of the evidence, the damages awarded are excessive, the trial was unfair, or prejudicial error was committed in its course." *Smith v. Transworld Drilling Co.*, 773 F.2d 610, 612–13 (5th Cir. 1985); *see also Laxton v. Gap Inc.*, 333 F.3d 572, 586 (5th Cir. 2003) ("A new trial is warranted if the evidence is against the great, and not merely the greater, weight of the evidence."). Furthermore "[u]nless justice requires otherwise, no error in admitting or excluding evidence—or any other error by the court or a party—is ground for granting a new trial . . . . the court must disregard all errors and defects that do not affect any party's substantial rights." Fed. R. Civ. P. 61.

## III. Discussion

Apple argues it is entitled to a new trial because the jury trial was held without evidence regarding Optis's obligation to license the patents on FRAND terms. (Dkt. No. 549 at 9.) The jury's verdict in this case, Apple argues, is not compliant with FRAND terms and stands in violation of the FRAND limitations on reasonably royalty awards for standard essential patents. (*Id*. at 13–14.) Apple contends that at a minimum, damages should be retried, while maintaining that a new trial regarding all issues is appropriate given that the exclusion of FRAND "had prejudicial effects that went beyond damages." (*Id*. at 15.) Apple further argues that by failing to plead an affirmative FRAND counterclaim or defense, it did not waive its right to challenge the verdict as not being FRAND-compliant. (*Id*. at 15–19.)

Optis responds that the jury's verdict is FRAND-compliant, despite the lack of any mention of FRAND principles or obligations before the jury. (Dkt. No. 577 at 6.) Optis argues that FRAND obligations need not specifically be mentioned, so long as the jury was instructed on the principles embodied by FRAND. (*Id.* at 5–6.) Specifically, Optis argues that the jury was properly instructed regarding the standard for a reasonable royalty, including that the jury "must not award Optis more

damages than are adequate to compensate for the infringement." (*Id*. at 5 (citing Dkt. No. 520 at 985:23–24).) Optis further points to the SEP-related instructions that "the patented feature must be apportioned from all the unpatented features reflected in the standard," and "the patent owner's royalty must be premised on the value of the patented feature, not any value added by the standard's adoption of the patented technology." (*Id*. at 5–6 (citing Dkt. No. 520 at 991:6–14).) Optis argues that these collective instructions—accompanied by expert testimony regarding the same—adequately tether the jury's verdict to the FRAND framework set forth in *Ericsson, Inc. v. D-Link Sys., Inc.*, 773 F.3d 1201, 1232 (Fed. Cir. 2014). (Dkt. No. 577 at 5–8.)

To be clear, the unique posture of the jury trial followed by the bench trial with respect to FRAND issues resulted from a series of intentional decisions made by both parties. Pursuant to Count VIII of the First Amended Complaint, Optis initiated the request for FRAND relief which it affirmatively sought in this case. However, Optis could not simply wish away the intertwined nature of its own purported FRAND compliance with various allegations of bad acts and bad faith by Apple. (Dkt. No. 26 ¶¶ 140–46.) Said another way, Optis intentionally placed itself in a position to tell the jury only about Apple's bad acts without telling them of their own obligations to act in good faith. Optis created this disjointed predicament by electing to try its declaratory judgment claim to the bench instead of the jury. At the pretrial conference, the Court repeatedly sought to confirm Optis's intentions with respect to its declaratory judgment claim, and Optis unequivocally stated that it intended to try the FRAND issues to the bench. (Dkt. No. 435 at 54:5–55:3.) At this same time, Apple said nothing and did nothing—almost as if they were not there.

It was this interchange during the pretrial conference which caused the Court to exclude FRAND evidence from the trial altogether. Freed from telling the jury of its affirmative FRAND duties and obligations, Optis attempted to leverage its willfulness claim to introduce evidence

before the jury of bad faith and bad acts by Apple during pre-suit licensing negotiations. (Dkt. No. 435 at 57:13–58:9; Dkt. No. 436 at 36:2–23.) The Court recognized, however, that this was core FRAND evidence relating to Optis's declaratory judgment claim, which both parties had seemed to agree at pretrial should be tried solely to the bench. As a result, the Court ruled that the declaratory judgment claim as to FRAND could not be treated in this way. (Dkt. No. 435 at 62:14–23.) The Court noted that had Optis chosen to present its declaratory judgment claim to the jury, it would have been able to present evidence of Apple's alleged bad faith and holdout, and "all the testimony about whether the damages are or are not FRAND would have come in before the jury." (Dkt. No. 435 at 57:18–25.) As a result, Optis cannot now be heard to argue that its decision to consciously take FRAND evidence away from the jury has no impact on the FRAND-compliance of the jury's verdict.

For its part, Apple agreed in the Joint Pretrial Order that Optis's declaratory judgment claim was to be tried to the bench. (Dkt. No. 360 at 4.) After the Court clearly detailed the roadmap for trial as to the outstanding FRAND issues, Apple failed to object. In fact, Apple was wholly mute. (Dkt. No. 435 at 56:25–57:9; Dkt. No. 437 at 20:23–21:2; Dkt. No. 538 at CL12 n.4.) The Court repeatedly emphasized that by acquiescing in Optis's request that Count VIII be tried to the bench, Apple would not be able to present its damages analysis regarding FRAND to the jury. (Dkt. No. 435 at 56:25–57:9, 59:4–61:7.) Again, Apple was mute. As a result, the Court's ruling was structured to ensure that neither side could unfairly capitalize on the structure of the trials with respect to FRAND. Despite Apple's post-trial epiphany regarding the absence of FRAND evidence from the jury trial, Apple received a significant benefit by staying strategically silent during pretrial proceedings, preventing the jury from hearing potentially harmful evidence regarding Apple's alleged bad faith conduct or holdout. This reasonably explains Apple's muteness at pretrial. As

noted during the pretrial conference and in the Court's Findings of Fact and Conclusions of Law following the bench trial, if Apple wanted to ensure its ability to introduce a FRAND-related damages analysis to the jury, it could (and should) have brought a counterclaim or even raised an affirmative defense to that effect. (Dkt. No. 435 at 56:25–57:9; Dkt. No. 538 at CL8–13.) It did not.[2] (Dkt. No. 538 at CL 12.)

Despite the resulting structure of the two trials (jury and bench) that have now taken place in this case, the Court is persuaded that the FRAND-compliance of the damages awarded by the jury has legitimately been called into question. Given that the patents found to be infringed are FRAND-encumbered SEPs, any royalty awarded must be FRAND. (Dkt. No. 26 ¶ 142; Dkt. No. 360 at 17); *Ericsson*, 773 F.3d at 1229–31. To be sure, the jury's verdict *may* be consistent with FRAND terms. However, the jury never had any evidence that Optis's patents were in fact FRAND-encumbered, nor did the jury hear any evidence as to what royalties would or could be FRAND. As a result, the verdict does not necessarily represent a FRAND royalty. Consequently, the absence of FRAND evidence and instructions to the jury casts serious doubt on the reliability of the verdict, and a new trial regarding damages is warranted. This is the case notwithstanding the culpability of both parties in this matter. While the Court is very much aware of the strategic choices made by Optis and Apple as to how the FRAND issues would be adjudicated, the Court's primary duty is to see that justice is done. In large part because of the conscious acts of both parties, the Court now finds itself left with a very large damages award made as to SEPs where the jury never heard the acronym FRAND or heard evidence about how that concept impacted a fair damages award in this case. In the Court's view, this requires a new trial on damages.

[2] With the benefit of hindsight, it is apparent to the Court that both sides played fast and loose with the FRAND issue before the jury for their own strategic reasons.

The Court is not persuaded, however, that a new trial on the entirety of the case is warranted. Apple argues that Optis improperly "argued that Apple had willfully infringed the Asserted Patents as part of a strategy to delay making royalty payments." (Dkt. No. 549 at 14.) Apple claims that the exclusion of FRAND evidence from the jury trial precluded it from rebutting this narrative. (*Id*.) The Court does not find this to be an adequate basis for a new trial regarding liability. The Court instructed the jury separately regarding the issues of willfulness and damages (Dkt. No. 520 at 64:24–66:9), and the Court must presume that the jury correctly followed the Court's instructions. *See Zafiro v. United States*, 506 U.S. 534, 540–41 (1993). Further, even though the jury found that Apple's infringement was willful, the Court declined to enhance damages under 35 U.S.C. § 284, negating any tangible impact to Apple from the jury's willfulness finding. (Dkt. No. 544.) The Court concludes that the issues relating to willful infringement are separate and distinct from those relating to damages, and a new trial regarding liability is neither necessary nor warranted.

## IV. Conclusion

Based on the foregoing, the Court finds that Apple's Motion for New Trial should be and hereby is **GRANTED** as to damages. In all other respects, including as to liability, Apple's Motion for New Trial is **DENIED**. Accordingly, the Judgment against Apple in this case (Dkt. No. 544) is **VACATED** as to damages. The parties are ordered to meet and confer and within two weeks from this date submit a jointly proposed docket control order providing for a new trial as to damages only.

**So ORDERED and SIGNED this 14th day of April, 2021.**

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

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| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, and PANOPTIS PATENT MANAGEMENT, LLC, | ) | Case No. 2:19-cv-00066-JRG |
| Plaintiffs, | ) | July 26, 2021 |
| vs. | ) | 10:15 a.m. |
| | ) | MARSHALL, TEXAS |
| APPLE, INC. | ) | |
| Defendant. | ) | |

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REPORTER'S SEALED TRANSCRIPT OF
FINAL PRETRIAL CONFERENCE

BEFORE THE UNITED STATES
CHIEF JUDGE JAMES R. GILSTRAP

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MR. JERRY HADDAD
MR. JOHN HUYNH
MR. JUSTIN CHAUNCEY

COURT REPORTER:

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over by your Honor. Or some theoretical claim we don't even have in this case.

It is a very limited, discreet task before the jury at this point. And to introduce this evidence would, again, just to say it one more time, create a circus and a sideshow having nothing to do with that task, violate Rule 408, run afoul of least the spirit, if not the letter, of the parties' NDA. And we just think it's not right for all those reasons, your Honor. We think the jury should keep their eye on the ball and apply your Honor's instructions as to what FRAND means to the two parties' respective positions as to what FRAND royalties would be for these five patents. Period.

THE COURT: All right. Well, I agree that the precise FRAND obligation is not defined by ETSI in precise detail. I don't agree that it has no real meaning. And it is for this jury to determine if the FRAND obligation, which encumbers these patents, has been complied with.

In my mind, despite Apple's argument to the contrary -- what Apple argues is a sideshow -- to me is a part of putting forward before the jury the information they will need to determine if the conduct between these parties has been fair, reasonable, and

non-discriminatory. And that relates to the hypothetical negotiation in 2012. I think that's also informed by what happened subsequently. I don't agree with Apple that the Court has to draw a bright line at 2012 and say nothing and no evidence about anything post 2012 can come in.

I don't agree that the FRAND obligation has no relation to the monetary amount of the exchanged offers. An offer made, an offer wasn't accepted, and the FRAND obligation was met. That makes the FRAND obligation mean nothing. It's got to be viewed in the context of the actual monetary financial context of the offer and how it relates to the functionality that's at issue.

With that said -- within the context of Apple's MIL No. 4, I'm going to deny Apple's MIL No. 4. And I'm not going to draw a bright line at 2012 and say nothing beyond that date can be presented to this jury. I don't intend this to devolve into a sideshow, and I'm going to do everything I can to make sure it doesn't. But the jury is entitled to view the totality of the conduct both by the current patent owner and their predecessors and the intended licensee in determining if the spirit of FRAND and the obligation has been complied with or has not been complied with.

COURT REPORTER'S CERTIFICATION

I HEREBY CERTIFY THAT ON THIS DATE, July 28, 2021, THE FOREGOING IS A CORRECT TRANSCRIPT FROM THE RECORD OF PROCEEDINGS.

APRIL D. HARGETT, RPR, RVR

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § | |
| *Plaintiffs*, | § | |
| v. | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| APPLE INC., | § | |
| *Defendant*. | § | |

## MEMORANDUM OPINION AND ORDER

Before the Court are the following motions filed by Defendant Apple Inc. ("Defendant" or "Apple"):

1. **Apple Inc.'s Rule 50(B) Motion #1 for Judgment as a Matter of Law of No Liability Under the '557, '332, '774, and '833 Patents** (the "First JMOL Motion") (Dkt. No. 554);

2. **Defendant's Rule 50(b) Motion #2 for Judgment as a Matter of Law of No Liability on the '284 Patent and of No Indirect or Willful Infringement of Any Patent** (the "Second JMOL Motion") (Dkt. No. 555);[1]

[1] The Second JMOL Motion exceeds the page limits set forth in Local Rules CV-50 and 7(a)(3), and Apple filed an Unopposed Motion to File Corrected 50(b) Motion #2 for Judgment as a Matter of Law of No Liability on the '284 Patent and of No Indirect or Willful Infringement of Any Patent (Dkt. No. 563). Since the relief requested in the Second JMOL Motion is denied herein, Dkt. No. 563 is hereby **DENIED AS MOOT**.

3. **Defendant's Rule 50(b) Motion for Judgment as a Matter of Law Regarding Damages** (the "Damages JMOL Motion") (Dkt. No. 557); and

4. **Apple Inc.'s Supplemental Motion For A New Trial** (the "Motion for New Trial") (Dkt. No. 578).

Having considered these Motions, and for the reasons stated herein, the Court finds that the Motions should be **DENIED** on all grounds except as to contributory infringement. As to contributory infringement, it is undisputed that no evidence was presented at trial, so JMOL is **GRANTED**.

## I. BACKGROUND

Plaintiffs Optis Wireless Technology, LLC; Optis Cellular Technology, LLC; Unwired Planet, LLC; Unwired Planet International Limited; and PanOptis Patent Management, LLC (collectively, "Plaintiffs" or "Optis") filed suit against Apple alleging that Apple's products[2] (the "Accused Products") infringe U.S. Patent Nos. 8,019,332 (the "'332 Patent"), 8,385,284 (the "'284 Patent"), 8,411,557 (the "'557 Patent"), 9,001,774 (the "'774 Patent"), 8,102,833 (the "'833 Patent") (collectively, the "Asserted Patents"). (Dkt. No. 26).[3] The Court conducted a jury trial with respect to the Asserted Patents from August 3, 2020 through August 11, 2020. (Dkt. Nos.

[2] For the '774 Patent, the Accused Products were: the iPad (3rd generation), iPad mini, iPad (4th generation), iPad Air, iPad mini 2 with Retina display, iPad Air 2, iPad mini 3, iPad Pro (12.9-inch), iPad mini 4, iPad Pro (9.7-inch), iPad (5th generation), iPad Pro (12.9-inch) (2nd generation), iPad Pro (10.5-inch), iPad (6th generation), iPad Pro 11-inch, iPad Pro 12.9-inch (3rd generation), iPad Air (3rd generation), iPad mini (5th generation), iPhone 5, iPhone 5c, iPhone 5s, iPhone 6, iPhone 6 Plus, iPhone 6s, iPhone 6s Plus, iPhone SE, iPhone 7, iPhone 7 Plus, iPhone 8, iPhone 8 Plus, iPhone X, iPhone XS, iPhone XS Max, iPhone XR, iPhone 11 Pro, iPhone 11 Pro Max, iPhone 11, Apple Watch Series 4, Apple Watch Series 5. (Dkt. No. 360 at 20). For the '332, '284, '557, and '833 Patents, Plaintiffs also accused the Apple Watch Series 3. (Dkt. No. 360 at 20–21; Dkt. No. 501 at 160:13–21). The additional allegation of infringement against the Apple Watch Series 3 against four of the Asserted Patents does not alter the Court's analysis herein, and the Court globally refers to the accused products with respect to the '774 Patent as the Accused Products.

[3] Plaintiffs also alleged infringement of U.S. Patent Nos. 8,005,154 and 8,989,290, but those allegations were withdrawn before trial. (*Compare* Dkt. No. 1, *with* Dkt. No. 490 at 182:1–21).

460, 461, 466, 474, 482, 485, 486). At the close of evidence, the parties moved for judgment as a matter of law pursuant to Federal Rule of Civil Procedure 50(a). (*See* Dkt. No. 499). Among the Rule 50(a) motions heard by the Court were Defendant's motions for judgment as a matter of law of non-infringement, no willful infringement, and invalidity of the Asserted Patents, and no damages. (*Id*. at 929:7–931:16).

On August 11, 2021, the jury returned a verdict finding that Defendant infringed one or more claims asserted by Plaintiffs, such claims being Claims 1 and 10 of the '557 Patent, Claims 6 and 7 of the '332 Patent, Claim 6 of the '774 Patent, Claim 8 of the '833 Patent, and Claims 1, 14, and 27 of the '284 Patent (collectively, the "Asserted Claims"); that none of the Asserted Claims are invalid; that Defendant's infringement of the Asserted Patents was willful; and that Plaintiffs were entitled to $506,200,000.00 for infringement of the Asserted Patents, in the form of a royalty for past sales only. (Dkt. No. 483). The Court entered Final Judgment on February 25, 2021, memorializing the jury's findings but electing not to enhance damages for willful infringement under 35 U.S.C. § 284. (Dkt. No. 544).

On April 14, 2021, the Court granted a new trial as to damages in the above-captioned case, vacating as to damages the Court's previous Judgment. (Dkt. Nos. 544, 585). The Court found that a new trial on damages was warranted as to the amount of a fair, reasonable, and nondiscriminatory ("FRAND") royalty for the use of the Asserted Patents. (Dkt. No. 585 at 9). The Court declined, however, to grant a new trial as to liability. (*Id*. at 10).

## II. APPLE'S JMOL MOTIONS

Pursuant to Federal Rule of Civil Procedure 50(b), Defendant filed JMOL Motions seeking judgment as a matter of law of: (1) non-infringement, no willful infringement, and invalidity of the Asserted Claims of the Asserted Patents; and (2) no damages. (*See* Dkt. Nos. 554, 555, 557).

The Court finds that substantial evidence exists supporting the jury's verdict on each of the grounds raised by Defendant.

**A. Legal Standard**

"Judgment as a matter of law is proper when 'a reasonable jury would not have a legally sufficient evidentiary basis to find for the party on that issue.'" *Abraham v. Alpha Chi Omega*, 708 F.3d 614, 620 (5th Cir. 2013) (quoting Fed. R. Civ. P. 50(a)). The non-moving party must identify "substantial evidence" to support its positions. *TGIP, Inc. v. AT&T Corp.*, 527 F. Supp. 2d 561, 569 (E.D. Tex. 2007). "Substantial evidence is more than a mere scintilla. It means such relevant evidence as a reasonable mind might accept as adequate to support a conclusion." *Eli Lilly & Co. v. Aradigm Corp.*, 376 F.3d 1352, 1363 (Fed. Cir. 2004).

"The Fifth Circuit views all evidence in a light most favorable to the verdict and will reverse a jury's verdict only if the evidence points so overwhelmingly in favor of one party that reasonable jurors could not arrive at any contrary conclusion." *Core Wireless Licensing S.A.R.L. v. LG Elecs., Inc.*, 880 F.3d 1356, 1361 (Fed. Cir. 2018) (citing *Bagby Elevator Co. v. Schindler Elevator Corp.*, 609 F.3d 768, 773 (5th Cir. 2010)). A court must "resolve all conflicting evidence in favor of [the verdict] and refrain from weighing the evidence or making credibility determinations." *Gomez v. St. Jude Med. Daig Div. Inc.*, 442 F.3d 919, 937–38 (5th Cir. 2006).

**B. Discussion**

**a. THE FIRST JMOL MOTION**

Apple argues that it is entitled to judgment as a matter of law on the basis that Plaintiffs did not present sufficient evidence to support a finding of liability for infringement of the '557, '332, '774, or '833 Patents. (Dkt. No. 554 at 5). For each patent, Apple challenges the sufficiency of the evidence with respect to direct infringement and validity. (*See id.* at 5–32).

**i. The ’557 Patent**

Defendant provides five arguments to support its position of no direct infringement of the ’557 Patent: first, the Accused Products do not infringe because they do not have a “plurality of sequences … that are generated from a plurality of base sequences”; second, the Accused Products do not “select a sequence from a plurality of sequences”; third, that the Accused Products do not “partition[] the predetermined number of sequences”; fourth, that method claim 10 was not used in the United States; and fifth, that Plaintiffs failed to prove that the Accused Products infringed claims 1 and 10 under the doctrine of equivalents (“DOE”) (*Id.* at 5–14).

**1. Direct Infringement**

*i. “sequences … that are generated from a plurality of base sequences”*

Claims 1 and 10 of the ’557 Patent recite “sequences … that are generated from a plurality of base sequences.” (Dkt. No. 554 at 5). Defendant contends that Plaintiff did not show that “base sequences” are used to generate the required sequences. (*Id.*). Instead, Defendant argues that no reasonable jury could have concluded that the Accused Products met this limitation because the evidence at trial showed that the Accused Products “generate a *single* sequence from parameters, not from the required *plurality* of base sequences.” (*Id.* at 7) (emphasis in original). Defendant argues that Plaintiffs’ expert Dr. Madisetti failed to show that either the Accused Products practice this claim limitation or that the LTE standard requires the same. (*Id.* at 5–7).

In response, Plaintiffs argue that Dr. Madisetti testified that Defendant practices the portion of the LTE standard that satisfies this claim limitation. (Dkt. No. 588 at 10) (citing Dkt. No. 502 at 19:1–12; PX940, PX1005). In addition, Plaintiffs assert that Dr. Madisetti analyzed the relevant Qualcomm and Intel source code to further support his conclusion that the Accused Products

practice this limitation. (Dkt. No. 588 at 11–12) (citing Dkt. No. 502 at 25:4–14; PX0119; PX0120).

The Court finds substantial evidence to support a finding of infringement for this claim limitation. With respect to the LTE standard, Dr. Madisetti explained that "Section 5.7.2 and Tables 5.7.3.4 and 5.7.2.2 explicitly disclose the portions of the claim that are described here, the plurality of base sequences generated from the Zadoff-Chu. There's a plurality in plural. And there's several of them." (Dkt. 502 at 17:24–18:6; *see also* PX0935). Dr. Madisetti also testified that sequences, *i.e.*, "random access preambles," are "generated from Zadoff-Chu sequences," which are in turn generated from "several Zadoff-Chu sequences." (Dkt. No. 502 at 17:24–18:6; PX0935). Dr. Madisetti identified the "several Zadoff-Chu sequences" as "the plurality of base sequences." This is substantial evidence that the Accused Products include "sequences … that are generated from a plurality of base sequences," as recited in claims 1 and 10. The jury was entitled to accept Dr. Madisetti's testimony and reject the testimony of Defendant's experts that the Accused Products do not operate according to the relevant portions of the LTE standard.

*ii. "select a sequence from a plurality of sequences"*

Defendant argues that no reasonable jury could have found that Accused Products "select a sequence from a plurality of sequences," as required by claims 1 and 10 of the '557 Patent. (Dkt. No. 554 at 8). Rather, Defendant contends that Dr. Madisetti identified only a "sequence index" and a "single generated sequence of values." (*Id*.). According to Defendant, a "sequence index" is not a "sequence" and a "single generated sequence of values" is not a "plurality of sequences." (*Id*.). Both sides' experts agreed, Defendant argues, that a sequence must comprise a *set* of values, rather than a single value—i.e., a "sequence index." (*Id*. at 8–9).

Plaintiffs argue that Defendant's argument is based on Defendant's expert Mr. Lanning's interpretation of the term "sequence" as "a set of values in a specific order." (Dkt. No. 588 at 13). Plaintiffs argue that the term "sequence" is not so limited, and assert that Defendant failed to seek construction of this term. (*Id*.). Plaintiffs contend that Dr. Madisetti described where the '557 Patent describes selecting a sequence by an index and argues that this analysis was properly performed within his understanding of the term "sequence." (*Id*. at 14) (citing Dkt. 502 at 19:13–18; Dkt. No. 507 at 76:2–7).

Dr. Madisetti described the relationship in the '557 Patent between sequences and sequence indexes and showed how selecting a random access preamble by a corresponding index falls within the claim scope. (Dkt. 507 at 76:2–7, 76:10–19). This testimony did not run afoul of any of the Court's claim constructions, as the term "sequence" was not construed. Dr. Madisetti also explained that one random access preamble is selected out of the plurality of 64 random access preambles. (Dkt. 502 at 19:1–10, 24:12–23). Thus, the Court finds that Plaintiffs presented substantial evidence as to this limitation.

*iii. "partition[] the predetermined number of sequences"*

Defendant argues that Plaintiffs failed to show that Accused Products partition sequences. (Dkt. No. 554 at 10–11). At best, Defendant contends, Plaintiffs' expert Dr. Madisetti provided testimony that groups are partitioned, but his testimony did not show that specific sequences are partitioned or demonstrate the relationship between groups and sequences. (*Id*.). Defendant argues that, by contrast, its own expert Mr. Lanning described how the Accused Products use "on the fly" sequence transmission to directly determine which sequence needs to be transmitted and then transmitting it. (*Id*. at 11).

Plaintiffs respond that Dr. Madisetti testified that in the LTE standard, 64 preambles—*i.e.*, the "predetermined number of sequences"—are grouped into Group A or Group B. (Dkt. No. 588 at 14–15) (citing Dkt. No. 502 at 14:13–25). These 64 sequences, Plaintiffs argue, vary between Group A and Group B based on control information, and therefore specific sequences (not merely groups) are partitioned into Group A or Group B. (Dkt. No. 588 at 15) (citing Dkt. No. 502 at 24:4–23).

The Court finds that Plaintiffs presented substantial evidence that the Accused Products "partition[] the predetermined number of sequences." Dr. Madisetti testified that specific predetermined sequences, not just groups, are partitioned. (Dkt. No. 502 at 14:13–25) ("So the partitioning is confirmed, the size variation is confirmed, and further, as you can see in this control information, the size of the -- the total number of preambles varies between 4 and 64, while the size of Group A varies between 4 and 60. So the size can be varied, and Group B can also be varied as a result.").

*iv. Use of Method Claim 10 in the United States*

Defendant argues that Plaintiffs offered no evidence of actual infringing use of claim 10 in the United States. (Dkt. No. 554 at 11–12). Defendant argues that Dr. Madisetti did not conduct a separate analysis for claim 10, relying instead on his analysis for claim 1. (*Id.* at 11). Defendant further claims that "although Dr. Madisetti testified about Apple's alleged LTE testing, he failed to establish that Apple tested all LTE functionalities or those that Plaintiffs accuse of infringing [c]laim 10." (*Id.* at 12). This alleged failure, Defendant argues, violates case law holding that all method steps must be shown were performed in the United States. (*Id.* at 12) (citing *Finjan, Inc. v. Secure Computing Corp.*, 626 F.3d 1197, 1206 (Fed. Cir. 2010)).

In response, Plaintiffs argue that Dr. Madisetti testified that LTE TS 36.321 and 36.331 practice claims 1 and 10 of the ’557 Patent and described that those portions of the standard are mandatory. (Dkt. No. 588 at 15) (citing Dkt. No. 502 at 32:4–12). Plaintiffs also contend that Dr. Madisetti provided evidence that Defendant tested the relevant portions of the LTE standard in the United States. (Dkt. No. 588 at 15–16) (Dkt. No. 502 at 28:17–25, 29:3–25, 32:4–17).

Plaintiffs provided sufficient evidence from which the jury could reasonably conclude the Accused Products satisfied this limitation of claim 10. Dr. Madisetti testified as to testing of the LTE standard in the United States and provided a sufficient basis to the link the LTE standard to the recited functionality in claims 1 and 10. (*See* Dkt. No. 502 at 28:17–25, 29:3–25, 32:4–17; PX2855).

*v. Doctrine of Equivalents*

Defendant argues that Plaintiffs did not “provide particularized testimony and linking argument as to the insubstantiality of the differences between the claimed invention and the accused device or process, or with respect to the function, way, result test … on a limitation-by-limitation basis.” (Dkt. No. 554 at 12) (quoting *Texas Instruments, Inc. v. Cypress Semiconductor Corp.*, 90 F.3d 1558, 1567 (Fed. Cir. 1996)). Specifically, Defendant contends that Plaintiffs’ expert, Dr. Madisetti, discussed equivalence only with respect to “selecting a sequence” of claims 1 and 10, rather than the full limitation, which requires sequence selection “from a plurality of sequences … that are generated from a plurality of base sequences.” (Dkt. No. 554 at 12) (citing Dkt. No. 493 at 21:17–22:16; Dkt. No. 498 at 77:19–78:1). Defendant argues that its own experts, Mr. Lanning and Dr. Josiam, testified that the “[accused] products operate in a substantially different way by generating a sequence from parameters and selecting a sequence index to generate only a single sequence on the fly, not selecting a sequence from a plurality of generated

sequences." (Dkt. No. 554 at 13) (citing Dkt. No. 497 at 15:7–17:13, 863:16–869:16; Dkt. No. 496 at 24:24–28:1).

Plaintiffs respond by arguing that Dr. Madisetti explained that the function of selecting a sequence is satisfied by "the process of creating the table of sequences in the code, the process of selecting a sequence, and the process of generating the selected sequence." (Dkt. No. 588 at 17) (quoting Dkt. No. 502 at 22:1–6). Plaintiffs argue that for the DOE analysis, it was appropriate for Dr. Madisetti to build upon without repeating his prior testimony relating to literal infringement. (Dkt. No. 588 at 16–18).

The Court finds that Dr. Madisetti properly incorporated by reference his earlier testimony into the DOE analysis. (Dkt. 502 at 21:17–22:6). Dr. Madisetti further expanded upon that analysis to show insubstantiality between the claims and the Accused Products. (Dkt. No. 502 at 22:1–6, 21:8–16, 22:1–6). The Court finds that Plaintiffs presented substantial evidence to support a finding of infringement under the DOE as to this limitation.

**2. Validity**

Defendant argues that its expert, Mr. Lanning, presented a strong case that the Sutivong and Tan references rendered obvious claims 1 and 10 of the '557 Patent, and this testimony went unrebutted by Plaintiffs' expert Dr. Madisetti. (Dkt. No. 554 at 14–15). Defendant argues that once it presented persuasive evidence of invalidity, "the burden of going forward shift[ed] to … [Plaintiff] to present contrary evidence and argument." (*Id*. at 15) (quoting *Titan Tire Corp. v. Case New Holland, Inc.*, 566 F.3d 1372, 1376–77 (Fed. Cir. 2009)). However, Defendant contends that Dr. Madisetti merely testified that no single reference disclosed all claim elements and that the asserted references were before the PTO during examination. (*Id*.).

Plaintiffs respond that Mr. Lanning merely provided conclusory testimony regarding the obviousness of claims 1 and 10, as well as the motivation to combine the Sutivong and Tan references. (Dkt. No. 588 at 19). Plaintiffs argue this such general and conclusory testimony is insufficient under the relevant case law, particularly in the face of contrary testimony from Dr. Madisetti. (*Id.* at 19–20).

It was Defendant's burden to show, by clear and convincing evidence, that claims 1 and 10 were invalid. Defendant must now show that "the evidence points so overwhelmingly in favor of one party that reasonable jurors could not arrive at any contrary conclusion." *Core Wireless*, 880 F.3d at 1361. The Court does not find that the evidence does any such thing. With respect to Defendant's obviousness arguments, although Mr. Lanning testified that claims 1 and 10 of the '557 Patent were obvious in view of Sutivong and Tan, the jury was entitled to disregard such evidence.

**ii. The '332 Patent**

**1. Direct Infringement**

Claims 6 and 7 of the '332 Patent require "using a specific equation to calculate the starting point for searching an LTE control channel called the PDCCH: namely, a 'modulo 'C' operation, wherein 'C' is determined as 'floor(N/L).'" (Dkt. No. 554 at 16). Defendant argues that its products do not use the "floor(N/L)" operation, and instead use a fundamentally different *shift* calculation. (*Id.*). Defendant contends that Dr. Madisetti conceded that the Accused Products use a shift calculation but did not explain how the shift calculation literally infringes the claimed the "floor(N/L)" operation. (*Id.*).[4] Instead, Defendant argues, Dr. Madisetti "merely asserted that the claimed equation is 'implemented,'" which is insufficient. (*Id.*). Defendant contends that its own

[4] Plaintiffs did not advance an infringement theory under the doctrine of equivalents for the '332 Patent. (Dkt. No. 554 at 16) (citing Dkt. No. 493 at 440:19–25).

witnesses detailed how the shift calculations performed by the Accused Products are different from and are more efficient than the claimed "floor(N/L)" operation. (*Id*. at 17). For example, Mr. Lanning used source code to describe how the Accused Products use a shift calculation instead of a "floor(N/L)" operation and, consequently, "perform 36 million fewer processing steps every hour." (*Id*. at 17).

Plaintiffs respond that Dr. Madisetti provided independent theories for this limitation: (1) that the LTE standard recites the claimed "floor(N/L)" function, and the Accused Products practice the relevant portions of the standard; and (2) that the "floor(N/L)" was literally met by "the value of N right shifted by 1" in the source code for the Accused Products. (Dkt. No. 588 at 20). Plaintiffs assert that Dr. Madisetti testified that a shift is the same as a divide function such as the claimed "floor(N/L)" operation. (*Id*.) (citing Dkt. No. 493 at 445:17–446:6, 442:25 – 443:2, 447:21–448:6, 449:8–9, 474:14–24). Similarly, Plaintiffs argue that Defendant's expert, Mr. Lanning, admitted that a shift operation is really a divide operation. (Dkt. No. 588 at 21) (citing Dkt. No. 506 at 50:24–21:2).

The Court is persuaded that Plaintiffs introduced sufficient evidence regarding this limitation. Considering the infringement theory based on source code alone, Dr. Madisetti provided sufficient evidence that the shift function performed by the Accused Products literally infringes the claimed "floor(N/L)" operation. (*See* Dkt. No. 493 at 445:17–446:6, 442:25–443:2, 447:21–448:6, 449:8–9, 474:14–24).

**2. Validity**

Defendant argues that claims 6 and 7 of the '332 Patent are invalid as obvious in view of the Ericsson and Knuth references, and no reasonable jury could conclude otherwise. (Dkt. No. 554 at 18–20). Defendant states that Mr. Lanning testified that the Ericsson reference discloses

each limitation of claims 6 and 7, except for the specific claimed equation. (*Id*. at 19). Mr. Lanning then testified that Knuth disclosed that specific equation and testified regarding the motivation to combine the two references with a reasonable expectation of success. (*Id*.). Plaintiffs rebuttal, Defendant argues, did nothing to substantively undermine Mr. Lanning's obviousness analysis. (*Id*. at 20).

Plaintiffs respond that Mr. Lanning merely provided conclusory testimony regarding the obviousness of claims 6 and 7, as well as the motivation to combine or modify the Ericsson and Knuth references. (Dkt. No. 588 at 22–23). Plaintiffs argue this such general and conclusory testimony is insufficient under the relevant case law, particularly in the face of contrary testimony from Dr. Madisetti. (*Id*. at 22–23).

Defendant bore the burden to show by clear and convincing evidence that claims 6 and 7 were invalid. However, Defendant has not shown that reasonable jurors could not arrive at a conclusion contrary to that of its expert, Mr. Lanning. The jury was entitled to disregard Mr. Lanning's testimony that claims 6 and 7 of the '332 Patent were obvious in view of Ericsson and Knuth.

**iii. The '774 Patent**

**1. Direct Infringement**

*i. "receiving a processing parameter" limitation*

Defendant argues that no reasonable jury could have found the Accused Products infringe claim 6 of the '774 Patent, which requires "receiving" a "processing parameter" that that includes "at least one of a time delay, a phase rotation and a gain." (Dkt. No. 554 at 21) (citing PX-0005). Defendant contends that its own expert, Dr. Wells, explained how "the accused products construct a processing parameter on their own, and do not receive one." (*Id*. at 23). Defendant argues that

Dr. Mahon's identification of a "codebook index" as the "processing parameter" fails because the Accused Products derive the codebook index, rather than receive it, and the codebook index is not a "processing parameter." (*Id*.).

Plaintiffs argue that claim 6 simply requires that the accused device "receiv[e] a processing parameter," and that the processing parameter "includ[e]" one of a time delay, a phase rotation, or a gain. (Dkt. No. 588 at 24) (citing '774 Patent, Cl. 6). Plaintiffs contend that this limitation does not prescribe "how the gain or phase rotation information included in the processing parameter is extracted from the received processing parameter." (Dkt. No. 588 at 24). Accordingly, Plaintiffs argue that Dr. Mahon testified that the Accused Products receive "precoding information" which carries the processing parameter. (Dkt. No. 588 at 24) (citing Dkt. No. 501 at 60:10–16). Dr. Mahon then explained that certain tables in the LTE standard are used to determine the required phase rotation and gain information. (Dkt. No. 588 at 24) (citing Dkt. 501 at 60:17–61:16; PX2142 at 0050).

Plaintiffs provided sufficient evidence from which the jury could reasonably conclude the Accused Products satisfied this limitation. In particular, Dr. Madisetti testified that "processing information" is "receiv[ed]" through the precoding information, which contains "at least one of a time delay, a phase rotation and a gain." (Dkt. No. 588 at 24) (citing Dkt. No. 501 at 60:10–61:16, 61:21–62:11; PX2142).

*ii. "demodulating" limitation*

For the limitation in claim 6 reciting "demodulating the first data symbol and the second data symbol based on the processing parameter, the first pilot and the second pilot," Defendant argues that Plaintiffs offered nothing more than conclusory testimony from Dr. Mahon that this

element was satisfied. (Dkt. No. 554 at 24–25). Such conclusory testimony, Defendant argues, cannot suffice to show infringement by the Accused Products. (*Id.*).

In response, Plaintiffs argue that Dr. Mahon analyzed the relevant source code and testified that based on his analysis, the "demodulating" claim limitation was satisfied. (Dkt. No. 588 at 27) (citing Dkt. 501 at 65:11-66:6; PX0113, PX0120, PX0096, PX0094). Plaintiffs also argue that Apple did not contest infringement of this limitation at any point during trial. (Dkt. No. 588 at 27–28).

The Court is satisfied that Plaintiffs provided sufficient evidence from which the jury could reasonably conclude the Accused Products satisfied this limitation. The jury was entitled to rely on Dr. Mahon's analysis of the source code, especially since Defendant presented no evidence to the contrary regarding the "demodulating" limitation.

*iii. Use of Method Claim 6 in the United States*

Defendant argues that Plaintiffs offered no evidence of actual infringing use of claim 6 in the United States, and judgment as a matter of law is required. (Dkt. No. 554 at 25).

Plaintiffs responds that they presented evidence through Dr. Mahon that Defendant infringed claim 6 in the United States by showing testing through test logs. (Dkt. No. 588 at 28) (citing Dkt. No. 501 at 77:9–79:16; PX2362, PX1996).

The Court is satisfied that Plaintiffs provided sufficient evidence from which the jury could reasonably conclude the Accused Products performed claim 6 in the U.S. The jury was entitled to rely on Dr. Mahon's analysis of test logs to show testing in the United States.

*iv. Doctrine of Equivalents*

Defendant argues that Plaintiffs' doctrine-of-equivalents theory should fail because it "consisted only of cursory testimony parroting the function/way/result test and the same evidence

already offered for literal infringement." (Dkt. No. 554 at 25). As to the "function" prong of the DOE test, Defendant argues that Dr. Mahon failed to explain how the functions of "carrying the processing parameter information to the phone" and "customization of the signals that are coming to [the] phone" are substantially the same as the claimed function of "receiving a processing parameter." (*Id*. at 25–26). As to the "way" prong of the DOE test, Defendant contends Dr. Mahon failed to explain how carrying processing parameter information on a DCI format 2 message is substantially the same as "receiv[ing] bits of information that are a processing parameter," as recited in claim 6. (*Id*. at 26–27). Finally, Defendant argues that Dr. Mahon failed to describe how the result of accessing gain and phase rotation information from the codebook index is substantially the same as "receiving a processing a parameter." (*Id*. at 27–28).

Plaintiffs respond that Dr. Mahon explained that to the extent the Accused Products do not literally infringe this limitation, the function of selecting a "receiving a processing parameter" is satisfied by the DCI format 2 message which carries the codebook index. (Dkt. No. 588 at 29) (citing Dkt. No. 501 at 132:13–133:1). Plaintiffs contend that Dr. Mahon testified extensively that literal infringement occurs by receiving a DCI message and using a codebook index to derive gain and phase rotation information. (Dkt. No. 588 at 29–30) (citing Dkt. 501 at 66:11–18, Dkt. 507 92:20–93:5, 96:1–12). Plaintiffs argue that for the DOE analysis, it was appropriate for Dr. Mahon to build upon without repeating his prior testimony relating to literal infringement. (Dkt. No. 588 at 28–30).

The Court finds that Dr. Mahon properly incorporated by reference his earlier testimony into the DOE analysis. (Dkt. No. 501 at 132:13–133:1). Dr. Mahon further expanded upon that analysis to show insubstantiality between the claims and the Accused Products. (Dkt. 507 at 92:20–

93:5, 96:23–97:12, 96:1–12). The Court finds that Plaintiffs presented substantial evidence to support a finding of infringement under the DOE as to this limitation.

### 2. Validity

Defendant argues that its expert, Dr. Wells, explained how claim 6 of the ’774 Patent was invalid as obvious in view of the Murakami and Hottinen references. (Dkt. No. 554 at 28). Defendant further argues that Dr. Wells explained how Plaintiffs’ expert, Dr. Mahon, used an overbroad application of the “receiving a processing parameter” limitation to show infringement. (*Id*.). Under that infringement theory, Dr. Wells testified, the Murakami and Hottinen references rendered Claim 6 invalid. (*Id*.). Defendant asserts that no reasonable jury could disagree with Dr. Wells’ conclusion regarding the validity of claim 6. (*Id*.).

Plaintiffs respond that Defendant’s expert, Dr. Wells, failed to present any disclosure in the prior art of “processing parameter” being “based on a received uplink signal.” (Dkt. No. 588 at 31). Additionally, Plaintiffs contend that Dr. Wells failed to present any motivation to combine or modify the Murakami and Hottinen references. (*Id*.). Plaintiffs argue that this such general and conclusory testimony is insufficient under the relevant case law, particularly in the face of contrary testimony from Dr. Mahon. (Dkt. No. 588 at 30–31).

To overcome the jury’s finding of no invalidity, Defendant must now show “the evidence points so overwhelmingly in favor of one party that reasonable jurors could not arrive at any contrary conclusion.” *Core Wireless*, 880 F.3d at 1361. The Court finds that Defendant has failed to meet this burden, as the jury was entitled to disregard Dr. Wells’ testimony in favor of Dr. Mahon’s.

### iv. The ’833 Patent

#### 1. Direct Infringement

Defendant argues that JMOL of no infringement is warranted for claim 8 of the ’833 Patent because control and data signals in the Accused Products are not mapped on a “row-by-row” basis, as claimed. (Dkt. No. 554 at 28). First, Defendant argues that Dr. Madisetti provided conclusory testimony that the LTE standard requires the claimed mapping, but he did not show that the Accused Products practice that portion of the standard. (*Id*. at 28–29). Second, Defendant contends that Dr. Madisetti identified source code in the Intel and Qualcomm processors which discloses the claimed mapping, but he did not specify whether the information bits are mapped on a row-by-row or column-by-column basis. (*Id*. at 29–31). By contrast, Defendant states that two of its witnesses—Dr. Josiam and Dr. Wells—testified that both the Intel and Qualcomm processors in the Accused Products map control and data signals on a “column-by-column” basis. (*Id*. at 31–32).

Plaintiffs respond that Dr. Madisetti provide specific testimony that the LTE standard discloses row-by-row mapping of control and data signals. (Dkt. No. 588 at 31–32) (citing Dkt. No. 501 at 188:3–20). Plaintiffs assert that Dr. Madisetti testified that this portion of the LTE standard is mandatory, and “Apple’s products satisfy this claim limitation based on the standard.” (Dkt. No. 588 at 32) (citing Dkt. No. 501 at 188:23–189:4; Dkt. No. 502 at 32:1–12; PX2142). Plaintiffs argue that Dr. Madisetti also described how the Intel and Qualcomm source code confirms that the Accused Products map signals row-by-row. (Dkt. No. 588 at 32) (citing Dkt. No. 501 at 189:17–190:3, 191:9–12).

The Court finds substantial evidence that the Accused Products map signals on a “row-by-row” basis. Dr. Madisetti testified to the same, demonstrating infringement under both the mapping

to the LTE standard and his independent analysis of Intel and Qualcomm source code. (Dkt. No. 501 at 188:3–190:3, 191:9–12; Dkt. No. 502 at 32:1–12; Dkt. No. 507 at 66:17–69:23; PX2142 at 31–32).

#### 2. Validity

Defendant argues that its expert, Dr. Wells, explained how claim 8 of the ’833 Patent was invalid as obvious in view of the Maladi, Qualcomm, and Samsung references. (Dkt. No. 554 at 32). Defendant asserts that no reasonable jury could disagree with Dr. Wells’ conclusion that claim 8 was invalid. (*Id*.).

In response, Plaintiffs argue that Defendant did not present an element-by-element analysis or show any motivation to combine the Maladi, Qualcomm, and Samsung references. (Dkt. No. 588 at 35). Plaintiffs contend that Dr. Madisetti, on the other hand, explained why Dr. Wells’ invalidity opinions were insufficient—namely because collectively, the asserted references did not contain each claim limitation of claim 8. (Dkt. No. 588 at 35–36) (citing Dkt. No. 507 at 74:5–25).

The Court finds that substantial evidence supports the jury’s conclusion that Defendant failed to meet its heavy burden to show invalidity of Claim 8 by clear and convincing evidence. The jury was entitled to reject Dr. Wells’ testimony regarding invalidity.

### b. The Second JMOL Motion

Apple argues that it is entitled to judgment as a matter of law on the basis that Plaintiffs did not present sufficient evidence to support a finding of liability for (1) infringement of the ’284 Patent, and (2) indirect and willful infringement of all patents. (Dkt. No. 554 at 5). For the ’284 Patent, Apple challenges the sufficiency of the evidence with respect to direct infringement and validity. (*See id*. at 1–7). For all Asserted Patents, Defendant challenges the sufficiency of the evidence with respect to induced, contributory, and willful infringement. (*Id*. at 7–20).

**i. The ’284 Patent**

**1. Direct Infringement**

Claims 1, 14, and 27 of the ’284 Patent require a control information field (1) “wherein a first subset of the values is reserved for indicating the transport format,” (2) “a second subset of the values … is reserved for indicating the redundancy version,” and (3) “the first subset of the values contains more values than the second subset of the values.” (*Id*. at 6) (citing PX0003). Defendant argues that in the accused MCS Index from the LTE standard, fewer values are reserved for indicating the transport format (the first subset) than are reserved for indicating the redundancy version (the second subset). (*Id*. at 6). Defendant contends that under the LTE standard, “every MCS Index value (0-31) (32 values) is reserved for indicating a redundancy version, but fewer values (0-28) (29 values) are reserved for the transport format.” (*Id*. at 7). This configuration, Defendant argues, is the exact opposite what is claimed. (*Id*. at 6).

Plaintiffs respond that Dr. Mahon testified as to how Table 8.6.1-1 of the LTE standard satisfies this claim limitation. (Dkt. No. 589 at 6–7) (citing Dkt. No. 501 at 30:2–17). Plaintiffs contend that Dr. Mahon also explained how the Intel and Qualcomm source code references Table 8.6.1-1 to derive the TBS and RV values. (Dkt. No. 589 at 7) (citing Dkt. No. 501 at 31:21–32:2, 32:21–33:7). Plaintiffs explain that Defendant’s corporate witness, Dr. Josiam, testified that in the LTE standard, the first 28 rows (the first subset identified by Dr. Mahon) had TBS index values, and that in the last three rows (the second subset identified by Dr. Mahon) the TBS index value “is not present” but has changing RV values. (Dkt. No. 589 at 8). From this testimony, Plaintiffs argue that the jury could reasonably conclude the limitation was satisfied. Plaintiffs also point out that in its Claim Construction Order, the Court ruled that “whether a particular value, such as an index,

satisfied the 'reserved for indicating' limitation is an issue of fact for the jury.'" (Dkt. No. 589 at 6) (quoting Dkt. No. 130 at 33).

The Court finds that the jury was entitled to rely on Plaintiffs' evidence and reject Defendant's. Through Dr. Mahon, Plaintiffs provided substantial evidence to support a finding that "the first subset of the values contains more values than the second subset of the values." (*See*, *e.g.*, Dkt. No. 501 at 30:2–17, 31:21–32:2, 32:21–33:7).

**2. Validity**

Defendant argues that the claims must be interpreted the same way for infringement and invalidity, and states that it proved at trial that "any application of the claims that covered Apple's accused products would also have been rendered obvious by the prior art." (Dkt. No. 555 at 10). Defendant contends that Plaintiffs applied a "jointly encoded" approach for infringement, where a common field is used to indicate both the transport format and the redundancy version. (*Id*. at 10–11). This infringement theory, Defendant argues, was shown to be "nothing more than an obvious variation of the prior art's 'shared field' technique, used to indicate the same two parameters." (*Id*. at 10). Defendant contends that its expert, Dr. Beuhrer described that the Samsung reference disclosed "joint encoding," and argues that Plaintiffs' expert, Dr. Mahon, did not meaningfully rebut Dr. Beuhrer's testimony. (*Id*. at 11–12).

In response, Plaintiffs argue that Defendant offered only a conclusory element-by-element analysis and did not show any motivation to combine or modify the Samsung reference. (Dkt. No. 589 at 13). Plaintiffs contend that Dr. Mahon, on the other hand, explained why Dr. Buehrer's invalidity opinions were insufficient—namely due to the lack of motivation to combine and difficulty in making the proposed alteration. (Dkt. No. 589 at 14) (citing Dkt. No. 507 at 105:14–106:13).

Defendant has not shown that "the evidence points so overwhelmingly in favor of one party that reasonable jurors could not arrive at any contrary conclusion." *Core Wireless*, 880 F.3d at 1361. The jury was entitled to disregard Dr. Beuhrer's testimony that claims 1, 14, and 27 of the '284 Patent were obvious in view of the Samsung reference.

**ii. The Asserted Patents**

**1. Induced Infringement**

Defendant offers three bases in support of its argument for no induced infringement. First, Defendant argues that "Plaintiffs offered no evidence that any third party directly infringed any asserted claim." (Dkt. No. 555 at 12). Second, Defendant argues that "Plaintiffs offered no evidence that Apple had 'knowledge of the patent in suit and knowledge of patent infringement.'" (*Id*.) (citing *Commil USA, LLC v. Cisco Sys., Inc.*, 135 S. Ct. 1920, 1926 (2015)). Third, Defendant argues that "the record is devoid of evidence to show that Apple specifically intended to cause infringement." (*Id*. at 16).

Defendant argues that Plaintiffs offered no evidence of third-party direct infringement or of actual infringing use in the U.S. for the asserted method claims. (Dkt. No. 555 at 12). As to the knowledge element, Defendant argues that the Plaintiffs alleged knowledge (or willful blindness) of the Asserted Patents based on a January 6, 2017 letter from Thomas Miller of Optis to Bruce Sewell of Apple to initiate licensing discussions of the Optis patent portfolio. (*Id*. at 13) (citing PX0548a) (the "2017 letter")). The 2017 letter stated that "a large number of [Optis's] patents and patent applications" had been declared standard essential and should be "of particular interest" to Apple. (PX0548a). Plaintiffs further argued that Apple "didn't go to an independent expert to have conversations with them regarding the patents" in response to the letter. (*Id*.). Defendant points out that Plaintiffs also argued knowledge of the Asserted Patents based on Defendant's access to

a standard industry database called "Innography," where subscribers can search for patents by owner. (*Id*.). Defendant's in-house lawyer, Ms. Heather Mewes, testified that Defendant "access[ed] this [Innography] database in 2018 to identify what portion of … declared essential patents are owned by PanOptis." (*Id*. at 13) (citing Dkt. No. 437 at 34:8–19). Defendant argues that Optis's portfolio contained many patents, only five of which are the Asserted Patents, and Plaintiffs offered no evidence that Defendant learned of the specific Asserted Patents through the Innography database. (*Id*. at 13–16). Defendant contends that this evidence, coupled with Defendant's strong belief in noninfringement, is insufficient to support a finding of inducement. (*Id*.).

Plaintiffs respond that they provided sufficient evidence that Defendant's customers directly infringe the Asserted Claims by using Accused Products connected to the LTE network. (Dkt. No. 589 at 15). For the '774 Patent, Plaintiffs assert that they provided evidence of test reports that showed the use of TM4 and DCI format 2 by Apple customers in the United States. (Dkt. No. 589 at 15) (Dkt. No. 501 at 60:10–16). For the '557 Patent, Plaintiffs point to evidence of transaction log data on RACH preambles being sent by mobile devices on LTE networks. (Dkt. No. 589 at 15) (citing Dkt. No. 502 at 29:3–25, 32:4–17; PX2855). For the '284 Patent, Plaintiffs argue that they introduced evidence that "Apple's devices cannot actually function or send any data to the base station without infringing Claim 14." (Dkt. No. 589 at 15) (citing Dkt.No. 501 at 13:1–7).

As to knowledge of the Asserted Patents, Plaintiffs argue that post-suit knowledge is legally sufficient for indirect infringement, especially since Plaintiffs only sought damages for infringing acts after the filing of the Complaint. (Dkt. No. 589 at 16) (citing *Cellular Commc'ns Equip. LLC v. HTC Corp.*, 323 F. Supp. 3d 870, 873-74 (E.D. Tex. 2018); *In re Bill of Lading*

*Transmission & Processing Sys. Patent Litig.*, 681 F.3d 1323, 1345 (Fed. Cir. 2012)). In addition, Plaintiffs argue that the record supports a finding of willful blindness. (Dkt. No. 589 at 17). Plaintiffs argue that Defendant had a list of Plaintiffs' declared-essential patents since receiving the 2017 Letter from Plaintiffs, which included the "specifications or parts of the standard in which the patents' claims are essential to those specific specifications in the standard." (*Id*. at 17) (citing Dkt. No. 491 at 279:11–17). Since Defendant had access to the Innography database, which contains "all of the declarations made by any party for standard essential patents," Plaintiffs argue that the evidence showed Defendant could have discovered the Asserted Patents but remained willfully blind to the same. (Dkt. No. 589 at 17) (citing Dkt. No. 495 at 643:9–644:10; Dkt. No. 503 at 12:12–13:9; Dkt. No. 504 at 69:3–7). Finally, Plaintiffs argue that Defendant's allegedly reasonable noninfringement arguments are insufficient to avoid liability because the jury could still find "knowledge of the underlying direct infringement … under the doctrine of willful blindness. (Dkt. No. 589 at 17–18) (quoting *Unwired Planet, LLC v. Apple Inc.*, 829 F.3d 1353, 1363 (Fed. Cir. 2016)).

As to specific intent to induce infringement, Plaintiffs argue by advertising the benefits of LTE such as speed, Defendant promoted the use of LTE, thereby promoting the use of the LTE standard-essential patents. (Dkt. No. 589 at 18) (citing PX0190, PX0337, PX0192). Similarly, Plaintiffs contend that because the Asserted Patents are standard-essential patents, Defendant's advertisement of the Apple devices' interoperability with the LTE standard means Defendant intended for its customers to use the patented LTE features. (Dkt. No. 589 at 19).

The Court finds substantial evidence that Defendant induced its customers to infringe the Asserted Patents. Post-suit notice of the Asserted Patents is sufficient to satisfy the knowledge required for induced infringement, as Plaintiffs are not seeking damages before the date of the

Complaint. *See Cellular Commc'ns Equip. LLC v. HTC Corp.*, 323 F. Supp. 3d 870, 873–74 (E.D. Tex. 2018); *In re Bill of Lading Transmission & Processing Sys. Patent Litig.*, 681 F.3d 1323, 1345 (Fed. Cir. 2012). Though Defendant believes its noninfringement defenses were reasonable, the jury was entitled to reject (and did reject) the same.

**2. Contributory Infringement**

Defendant asserts that Plaintiffs admitted their claim of contributory infringement lacked any supporting evidence and should not go to the jury. (Dkt. No. 555 at 17) (citing Dkt. No. 499 at 926:14–927:7). Plaintiffs do not dispute this argument in their response or sur-reply. (*See generally* Dkt. Nos. 589, 618). The Court notes that it did not instruct the jury as to contributory infringement, so, in effect, the claim was not before the jury. (Dkt. No. 499 at 40:19–79:11; Dkt. No. 483). However, given that there is no evidence in the record with respect to Plaintiffs' claim of contributory infringement, Defendant's motion for judgment as a matter of law should be and hereby is **GRANTED**.

**3. Willful Infringement**

Defendant argues that Plaintiffs failed to prove that it had knowledge of the Asserted Patents and thereafter "'acted egregiously, willfuly or wantonly' or with deliberate indifference to a high or excessive danger of infringement of the asserted patents." (Dkt. No. 555 at 17). As to the knowledge requirement, and as described *supra*, Plaintiffs argued pre-suit notice of the Asserted Patents based on the 2017 Letter and Defendant's access to the Innography database. (*Id*. at 18). Defendant argues that (1) the 2017 Letter did not constitute notice because it referred to Optis's large portfolio, and (2) "access to a patent database does not confer knowledge of any specific patent." (*Id*.).

Defendant also argues that Plaintiffs presented no evidence that Defendant engaged in any "misconduct beyond typical infringement"—a course of conduct held insufficient to support willfulness under *Halo Elecs., Inc. v. Pulse Elecs., Inc.*, 136 S. Ct. 1923, 1935 (2016). (*Id.* at 19). Defendant contends that Plaintiffs did not advance a copying theory, and Defendant independently designed and sold the Accused Products years before being contacted by Plaintiffs. (*Id.*). In addition, Defendant argues the record is devoid of evidence reflecting a subjective belief of infringement, and instead suggests a strong belief of noninfringement. (*Id.* at 21).

Defendant also presents a separate basis for JMOL as to willfulness. Defendant argues that due to the exclusion of FRAND evidence from the trial, any evidence regarding "holdout" strategy should have been excluded. (*Id.* at 22). However, Defendant argues that PX1537—a document discussing Defendant's FRAND licensing strategy—was improperly admitted because the exhibit pre-dates the earliest alleged notice date and because FRAND evidence was excluded from the jury trial. (*Id.*). Given the prohibition of any mention of FRAND, Defendant claims it was prevented from explaining the context of PX1537, and any jury determination of willfulness stemming therefrom is improper. (*Id.*). Defendant argues that it was a willing licensee and negotiated in good faith with Plaintiffs, and thus any infringement could not have been willful. (*Id.* at 24).

Plaintiffs respond with two arguments: (1) pre-suit knowledge is not required to establish willful infringement; and (2) the evidence discussed *supra* with respect to induced infringement shows Defendant had pre-suit knowledge of the Asserted Patents and its own infringement. (Dkt. No. 489 at 19–20) (citing *Packet Intelligence LLC v. NetScout Sys., Inc.*, 2019 WL 2375218, at *8 (E.D. Tex. June 5, 2019); *Huawei Techs. Co. v. T-Mobile U.S., Inc.*, 2017 WL 1129951, at *4 (E.D. Tex. Feb. 21, 2017)). Plaintiffs further argue that a willful state of mind can be inferred from

Defendant's implementation and continued use of the LTE standard—despite knowing of the declared-essential patents—as well as Defendant's failure to conduct a meaningful pre-suit investigation. (Dkt. No. 589 at 21–22).

The Court finds substantial evidence to support the jury's finding of willful infringement. Pre-suit knowledge is not required for willfulness, and here Defendant is not seeking damages for pre-suit infringement. The jury was entitled to reject Defendant's noninfringement defenses and find that Defendant "'acted egregiously, willfuly or wantonly' or with deliberate indifference to a high or excessive danger of infringement of the asserted patents." *Halo*, 136 S. Ct. at 1935. In addition, the issue of willfulness is effectively moot because even though the jury found that Defendant's infringement was willful, the Court acting separately has previously declined to enhance damages under 35 U.S.C. § 284, negating any tangible impact to Defendant from the jury's willfulness finding. (Dkt. No. 544).

#### c. The Damages JMOL Motion

Defendant seeks judgment as a matter of law of no damages. (*See generally* Dkt. No. 557). Plaintiffs responds that the evidence supported the jury's damages verdict. (*See generally* Dkt. No. 590).

As previously noted, the Court granted a motion for new trial on the issue of damages. Accordingly, this motion seeks relief which has already been granted, and the Damages JMOL Motion (Dkt. No. 557) is **DENIED AS MOOT**.

## III. DEFENDANT'S MOTION FOR NEW TRIAL

Pursuant to Federal Rule of Civil Procedure 59, Defendant moved for a new trial. (*See* Dkt. No. 578). The Court finds that none of the grounds asserted by Defendant compel setting aside the jury's verdict and granting a new trial.

**A. Legal Standard**

Rule 59 provides that a new trial may be granted on all or part of the issues on which there has been a trial by jury for "any reason for which a new trial has heretofore been granted in an action at law in federal court." Fed. R. Civ. P. 59(a). Notwithstanding the broad sweep of Rule 59, "courts do not grant new trials unless it is reasonably clear that prejudicial error has crept into the record or that substantial justice has not been done, and the burden of showing harmful error rests on the party seeking the new trial." *Metaswitch Networks Ltd. v. Genband US LLC*, No. 2:14-CV-00744, 2017 WL 3704760, at *2 (E.D. Tex. Aug. 28, 2017); *Erfindergemeinschaft UroPep GbR v. Eli Lilly & Co.*, 276 F. Supp. 3d 629, 643 (E.D. Tex. 2017). "A new trial may be granted, for example, if the district court finds the verdict is against the weight of the evidence, the damages awarded are excessive, the trial was unfair, or prejudicial error was committed in its course." *Smith v. Transworld Drilling Co.*, 773 F.2d 610, 612–13 (5th Cir. 1985); *see also Laxton v. Gap Inc.*, 333 F.3d 572, 586 (5th Cir. 2003) ("A new trial is warranted if the evidence is against the great, and not merely the greater, weight of the evidence."). Furthermore "[u]nless justice requires otherwise, no error in admitting or excluding evidence—or any other error by the court or a party—is ground for granting a new trial . . . . the court must disregard all errors and defects that do not affect any party's substantial rights." Fed. R. Civ. P. 61.

**B. Discussion**

Defendant seeks a new trial on non-infringement and invalidity of the Asserted Patents, willfulness, and damages. (*See generally* Dkt. No. 578). Defendant also argues that errors in the verdict form warrant a new trial and that damages should be remitted. (*Id*.).

**a. Willfulness**

Defendant argues that a new trial is warranted because the trial was structured to allow Plaintiffs to unfairly paint Defendant as a "holdout" during negotiations over Optis's SEPs, without giving Defendant a chance to properly rebut this narrative. (*Id*. at 7–9). Specifically, Defendant asserts that PX1537—a document discussing Apple's FRAND licensing strategy—was improperly admitted because the exhibit pre-dates the earliest alleged notice date and because FRAND evidence was excluded from the jury trial. (*Id*.). Given the prohibition on any mention of FRAND, Defendant claims it was prevented from explaining the context for the contents of PX1537. (*Id*.). Defendant further argues that Dr. Josiam and Mr. Ramaprasad—engineers who designed the Intel chips in the Accused Products—were improperly precluded from testifying to rebut willfulness, on the ground that their testimony improperly encroached on the realm of expert testimony. (*Id*. at 9–10).

Plaintiffs argue that PX1537 is relevant to willfulness and is not a FRAND document. (Dkt. No. 591 at 6). According to Plaintiffs, the FRAND redactions on the document are minimal because the document relates to standard-essential patent licensing, and as such, Plaintiffs' damages expert Mr. Kennedy discussed PX1537 in the context of the *Georgia-Pacific* factors. (Dkt. No. 591 at 7–8). Plaintiffs also assert that Defendant had the opportunity to effectively cross-examine Mr. Kennedy and rebut Plaintiffs' willfulness case. (*Id*. at 8–9). As to the testimony of Intel engineers Dr. Josiam and Mr. Ramaprasad, Plaintiffs argue that preclusion was proper because fact witnesses cannot properly compare the Accused Products to the LTE standard. (*Id*. at 9–10).

First, the Court notes that the word "FRAND" was redacted from PX1537 and the word "FRAND" was not mentioned to the jury. Second, "*no* error in admitting . . . evidence . . . is ground

for granting a new trial," unless justice mandates a new trial. Fed. R. Civ. P. 61 (emphasis added). This rule applies to the exclusion of certain of Dr. Josiam's and Mr. Ramaprasad's testimony. Third, the Court previously granted a new trial on damages where FRAND evidence will be presented. (Dkt. No. 585). In the Order granting the motion for new trial, the Court separately explained that although "the jury found that Apple's infringement was willful, the Court declined to enhance damages under 35 U.S.C. § 284, negating any tangible impact to Apple from the jury's willfulness finding." (Dkt. No. 585 at 10). Accordingly, the admission of a redacted version of PX1537 does not compel a new trial.

**b. Admission of Expert Evidence**

Defendant also argues that the testimony of several of Plaintiffs' experts should have been excluded. First, Defendant asserts that Plaintiffs improperly relied on opinions from non-testifying experts. (Dkt. No. 578 at 10). Specifically, Defendant argues that Dr. Mahon and Dr. Madisetti were permitted to channel the opinions of non-testifying source code expert Mr. Jones, testing expert Mr. Royer, and simulation expert Dr. Virdis. (*Id*.). According to Defendant, the admission of this evidence—combined with the Court's limitations on impeachment—barred Defendant from exposing key conflicts between the testifying and non-testifying experts' opinions. (*Id*. at 10–11).

Second, Defendant argues that Plaintiffs were improperly allowed to compare Defendant's products to disclosed embodiments in the Asserted Patents, rather than the Asserted Claims. (*Id*.). Despite an order *in limine* excluding "testimony about accused product[s] practicing the embodiments of the patent-in-suit," Defendant argues that for the '557 and '284 Patents, Plaintiffs were allowed to elicit testimony from multiple experts improperly comparing the specification to the Accused Products. (*Id*. at 11–12).

Third, Defendant argues the Court improperly excluded expert testimony regarding the ’284 Patent’s file history, “even though it was an admitted exhibit central to Plaintiffs’ expert’s theory.” (*Id*. at 13). Defendant contends that Plaintiffs used the file history of the ’284 Patent (PX0009) to support their expert’s opinion that the claims were satisfied because a “first subset of the values [reserved for indicating the transport format]” contains “more values than the second subset of the values [reserved for indicating the redundancy version].” (*Id*. at 12). According to Defendant, Plaintiffs then attacked Defendant’s expert Dr. Buehrer for excluding embodiments from the claims. (*Id*. at 12–13). The Court sustained objections to Defendant’s attempt to introduce the file history, rejecting the argument that Plaintiffs had opened the door. (*Id*. at 13). Defendant argues this exclusion warrants a new trial. (*Id*. at 12–14).

Plaintiffs respond that the Court was justified in limiting impeachment of the testifying experts who relied on non-testifying experts. (Dkt. No. 591 at 11–12). For example, Plaintiffs contend that Mr. Jones’ deposition testimony was properly excluded because his testimony was not disclosed in pretrial disclosures and he was not listed on Defendant’s witness list. (*Id*. at 11). As to the other non-testifying experts, Plaintiffs argue that the testifying experts, Dr. Madisetti and Dr. Mahon, conducted their own source code review and reached their own independent conclusions. (*Id*. at 12) (citing Dkt. No. 493 at 468:25–469:4; Dkt. No. 501 at 10:3–11:3).

Plaintiffs also argue that they did not compare disclosed embodiments in the Asserted Patents to the Accused Products, but rather used disclosed embodiments from the specification to show correlation to the LTE standard, as well as to educate the jury as to the relevant technology. (Dkt. No. 591 at 13–14). As to the file history for the ’284 Patent, Plaintiffs assert that the Court properly excluded the same because Defendant sought to explain how claim amendments over

time impacted the claims' meaning—an issue for the Court during claim construction, not for the jury. (*Id*. at 14).

The Court finds that Defendant's objection to the admission of expert testimony does not warrant a new trial. Testifying experts are allowed to rely on non-testifying experts as long as they fully explain he bases for their opinions. *See Monsanto Co. v. David*, 516 F.3d 1009, 1015 (Fed. Cir. 2008). Any error in admitting testimony regarding the non-testifying experts does not warrant a new trial. *See* Fed. R. Civ. P. 61. The Court also finds that Plaintiffs made no improper comparison of disclosed embodiments in the Asserted Patents to the Accused Products. Further, the '284 Patent file history was properly excluded because the time for claim construction had come and gone.

**c. Damages**

Defendant argues that a new trial on damages is warranted because (1) the Court denied Defendant's proposed instruction regarding the smallest saleable patent practicing unit (SSPPU); (2) the testimony of Plaintiffs' damages expert, Mr. Kennedy, should have been excluded; (3) Dr. Reed-Arthurs' testimony should have been excluded; and (4) Plaintiffs' references to pre-suit damages were unfairly prejudicial. (Dkt. No. 578 at 14–17). Alternatively, Defendant urges the Court to grant a remittitur. (Dkt. No. 578 at 8–11). As noted *supra*, the Court granted Defendant's motion for new trial on the issue of damages. Accordingly, this motion seeks relief which has already been granted, and Defendant's request for a new trial on damages is **DENIED AS MOOT**.

**d. Verdict Form**

Defendant makes several catch-all arguments in support of a new trial as to liability. First, Defendant argues that JMOL as to any patent requires setting aside the entire verdict. (*Id*. at 17). Second, Defendant contends JMOL of no infringement under DOE for either the '557 or '774

Patent requires setting aside the entire verdict. (*Id*. at 12). Third, Defendant argues a new trial is required because the verdict form violated its right to a unanimous verdict. (*Id*. at 20). Fourth, Defendant argues that if the Court grants a new trial on any issue, the Seventh Amendment requires a new trial on all issues. (*Id*. at 19). Each of Defendant's arguments boils down to an objection to Question 1 of the verdict form, which did not break down the infringement question by each patent claim and each product, as Defendant requested. (Dkt. No. 468-1 at 4; No. 483 at 4). The verdict form also did not separately break out questions for literal infringement and infringement under the doctrine of equivalents. (Dkt. No. 483 at 4).

Question 1 on the verdict form asked the jury, "[d]id Optis prove by a preponderance of the evidence that Apple infringed **ANY** of the Asserted Claims?" (Dkt. No.  at 4). The jury unanimously answered "yes" to that question. (*Id*.). The jury's answers to the remaining questions on the verdict form were consistent with their answers to this question. Further, as noted *supra*, sufficient evidence was presented to support Plaintiffs' infringement theories. *See Railroad Dynamics, Inc. v. A. Stucki Co.*, 727 F.2d 1506, 1516 (Fed. Cir. 1984) ("[W]hen a jury returns a general verdict, the law presumes the existence of fact findings implied from the jury's having reached that verdict.").

Defendant cites *i4i Ltd. P'ship v. Microsoft Corp.*, 598 F.3d 831, 849 (Fed. Cir. 2010), for the proposition that a general verdict must be set aside if it rests on multiple, independent legal theories—one of which is defective. (Dkt. No. 578 at 18). That case, however, distinguished between "defects in *legal* theories and defects in *factual evidence*." *i4i Ltd. P'ship*, 598 F.3d at 850 (emphasis in original). A general verdict will be upheld "if there was sufficient evidence to support *any* of the plaintiff's alternative factual theories," on the assumption that "the jury considered all the evidence and relied upon a factual theory for which the burden of proof was satisfied." (*Id*. at

849) (emphasis in original). Therefore, all that is required in this case is sufficient factual evidence supporting *either* of the independent theories of direct infringement (as to literal or the DOE) and induced infringement. (*See id*. at 598 F.3d at 850). The jury was properly instructed that it could rely on either theory (Dkt. No. 499 at 50:14–19, 63:20–64:23), and as discussed *supra*, the Court has found sufficient evidence under both theories. Accordingly, the Court finds that there was no error in submitting the verdict form as it did, and Defendant's request new trial as to liability is without merit.

## IV. CONCLUSION

For the reasons set for herein, Apple Inc.'s Rule 50(B) Motion #1 for Judgment as a Matter of Law of No Liability Under the '557, '332, '774, and '833 Patents (the "First JMOL Motion") (Dkt. No. 554); Defendant's Rule 50(b) Motion #2 for Judgment as a Matter of Law of No Liability on the '284 Patent and of No Indirect or Willful Infringement of Any Patent (the "Second JMOL Motion") (Dkt. No. 555); Defendant's Rule 50(b) Motion for Judgment as a Matter of Law Regarding Damages (the "Damages JMOL Motion") (Dkt. No. 557); and Apple Inc.'s Supplemental Motion For A New Trial (the "Motion for New Trial") (Dkt. No. 578) are each **DENIED**, except with respect to Plaintiffs' claim of contributory infringement, which is **GRANTED**.

**So ORDERED and SIGNED this 9th day of August, 2021.**

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § § § § § § | |
| *Plaintiffs*, | § § § | |
| v. | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| APPLE INC., | § § § | |
| *Defendant*. | § | |

**ORDER ON PRETRIAL MOTIONS *IN LIMINE***

The Court held a Pretrial Conference in the above-captioned matter on Monday, July 26, 2021 regarding pending motions *in limine* ("MILs") filed by Plaintiffs Optis Wireless Technology, LLC, Optis Cellular Technology, LLC, Unwired Planet, LLC, Unwired Planet International Limited, and PanOptis Patent Management, LLC (collectively, "Plaintiffs" or "Optis"), and Defendant Apple Inc. ("Defendant" or "Apple") (together with Plaintiffs, the "parties"). (Dkt. Nos. 633, 634). This Order memorializes the Court's rulings on the aforementioned MILs as announced from the bench into the record, including additional instructions given to the parties. While this Order summarizes the Court's rulings and directives as announced into the record during the pretrial hearing, this Order in no way limits or constrains such rulings from the bench. Accordingly, it is hereby **ORDERED** as follows:

## MOTIONS *IN LIMINE*

It is **ORDERED** that the Parties, their witnesses, and counsel shall not raise, discuss, or argue the following before the venire panel or the jury without prior leave of the Court:

### I. PREVIOUSLY GRANTED MOTIONS *IN LIMINE* (Dkt. Nos. 191, 192)

The Court ordered that the MILs which were granted in the previous Pretrial Conference in this case (*see* Dkt. No. 455 (Order On Pretrial Motions and Motions *In Limine*)) shall be re-entered and continue to apply to all parties. For the avoidance of doubt, the previous MILs granted by the Court are restated below:

**Previous Plaintiffs' MILs**

| | |
|---|---|
| Previous Plaintiffs' MIL 1 | Apple is precluded from offering lay witness infringement opinions. |
| Previous Plaintiffs' MIL 2 | Apple is precluded from offering the testimony of Christian Faber. |
| Previous Plaintiffs' MIL 4 | Apple is precluded from offering evidence of foreign patent prosecution history. |
| Previous Plaintiffs' MIL 5 | Apple is precluded from offering evidence on alleged inventor misconduct before the PTO. |
| Previous Plaintiffs' MIL 6 | Apple is precluded from referencing withdrawn patents. |
| Previous Plaintiffs' MIL 8 | Apple is precluded from making any disparaging remarks about the value and propriety of patents acquired from others. |
| Previous Plaintiffs' MIL 11 | Apple is precluded from making remarks about the quality of the PTO and its examiners. |
| Previous Plaintiffs' MIL 12 | Apple is precluded from making pejorative remarks about Optis's corporate structure and acquisition by Hilco. |
| Previous Plaintiffs' MIL 13 | Apple is precluded from arguing or introducing evidence as to practicing the prior art, or from comparing the accused products to anything other than the construed claims. |

| | |
|---|---|
| Previous Plaintiffs' MIL 14 | Apple is precluded from alleging that the predecessors of these patents (Samsung, Panasonic, LG) did not assert the patents-in-suit against Apple. |
| Previous Plaintiffs' MIL 18 | Apple is precluded from making reference to the absence of inventors at trial. |

**Previous Defendant's MILs**

| | |
|---|---|
| Previous Defendant's MIL 1 | Plaintiffs are precluded from making reference to evidence, arguments, verdicts, judgments, or orders from other litigations. |
| Previous Defendant's MIL 5 | Plaintiffs are precluded from offering evidence or arguments to the jury regarding French law. |
| Previous Defendant's MIL 8 | Plaintiffs are precluded from offering comparisons of the burden of proof standards to other areas of the law. |
| Previous Defendant's MIL 10 | Plaintiffs are precluded from offering evidence regarding Apple's foreign operations. |
| Previous Defendant's MIL 11 | Plaintiffs are precluded from making references to total corporate earnings, market capitalization, stock price, cash reserves, ability to pay or overall corporate indications of wealth in regard to either party. |
| Previous Defendant's MIL 12 | Plaintiffs are precluded from offering evidence or argument regarding witness compensation unrelated to this case. |
| Previous Defendant's MIL 13 | Plaintiffs are precluded from offering evidence regarding Steve Jobs, political positions taken by Apple or its leadership, media reports unrelated to this litigation, and/or media speculation about Apple. |
| Previous Defendant's MIL 14 | Plaintiffs are precluded from offering evidence that publishing patent applications or declaring patent applications to ETSI constitutes notice of alleged infringement. |

## II. PLAINTIFFS' MOTIONS *IN LIMINE* (Dkt. No. 634)

Plaintiff's MIL 1 **Any argument that FRAND places a limitation on a reasonable royalty.**

The MIL was **WITHDRAWN**. (Dkt. No. 651 at 79:1–9).

Plaintiff's MIL 2 **Any lay witness opinions regarding the value of the patents-in-suit or the underlying technology.**

The MIL was **DENIED**. (*Id*. at 158:8–159:16).

The Court noted that the rules of evidence already prohibit the coverage of the MIL. Lay witnesses should not offer opinion testimony within the realm of expert witnesses. Fact witnesses are not precluded from discussing subjects on which they have personal knowledge.

Plaintiff's MIL 3 **Any statement, argument, testimony, or evidence that references DX-171 or that the '332 Patent is "nothing new really"**

The MIL was **DENIED**. (*Id*. at 137:23–138:5).

The Court ordered the parties to meet and confer regarding the use of DX-171 in opening statements. The Court will take up any remaining disputes outside the presence of the jury.

Plaintiff's MIL 4 **Any statement, argument, testimony, or evidence challenging any objective indicia of non-obviousness.**

The MIL was **WITHDRAWN**. (*Id*. at 138:7–10).

Plaintiff's MIL 5 **Any discussion that the patents-in-suit were hard to find or are one of thousands.**

The MIL was **GRANTED-IN-PART** and **DENIED-IN-PART**. (*Id*. at 169:1–170:3).

The MIL was denied as to royalty stacking opinions disclosed in Dr. Perryman's expert report. The parties were ordered to seek leave of the Court before raising the issue of whether Apple appropriately searched ETSI databases to learn of the patents-in-suit.

Plaintiff's MIL 6 **Any statement, argument, testimony, or evidence regarding Huawei as a security risk or limited by the U.S. government.**

The MIL was **GRANTED-IN-PART** and **DENIED-IN-PART**. (*Id*. at 162:12–163:7).

The MIL was denied to the extent any testimony or argument relates to the raw numbers related to Huawei's sales. The MIL was granted in all other respects, including to the extent any testimony relates to why Huawei's sales are less than they otherwise would be.

Plaintiff's MIL 7 **Any statement, argument, testimony, or evidence regarding Plaintiffs' lack of licensing discussions with Qualcomm or Intel.**

The MIL was **DENIED**. (*Id*. at 102:3–8).

The Court noted that Apple is allowed to argue that Optis failed to apportion its requested royalty down to the smallest salable patent practicing unit (SSPPU) level. However, without prior leave of the Court, Apple should not argue that Optis has failed to sue or demand a license from Intel or Qualcomm.

Plaintiff's MIL 8 **Any reference to patent exhaustion or licenses with Qualcomm/Intel.**

The MIL was **GRANTED**. (*Id*. at 35:15–19).

The Court noted that patent exhaustion is a defense to liability, not a limitation on damages. Accordingly, exhaustion is not relevant to any issue in the upcoming damages trial.

Plaintiff's MIL 9 **Any new (post-first trial) 5G evidence.**

The MIL was **GRANTED**. (*Id*. at 150:16–25).

The Court noted that the set of relevant exhibits and permissible evidence is already established.

Plaintiff's MIL 10 **Any reference to whether inventors will benefit from the verdict.**

The MIL was **GRANTED**. (*Id*. at 163:8–15).

The Court noted that such evidence is irrelevant in the upcoming damages trial.

Plaintiff's MIL 11 **Any discussion of anyone other than Plaintiffs, LG, or Panasonic benefitting from the damages verdict.**

The MIL was **GRANTED**. (*Id*. at 163:19–17).

The Court noted that such evidence is irrelevant in the upcoming damages trial.

Plaintiff's MIL 12 **Any technical benefit analysis that relies on a theory of non-infringement or invalidity.**

The MIL was **GRANTED**. (*Id*. at 40:12–41:12).

The Court noted that Apple's request invites a retrial as to invalidity. The Court expects a minimal amount of technical testimony in the upcoming damages trial. The Court noted that the

sole issue in the upcoming trial is the appropriate FRAND royalty for the use of the standard-essential patents. The technical issues with respect to infringement and validity have already been decided.

Plaintiff's MIL 13 **Any reference to ongoing proceedings before the USPTO.**

The MIL was **GRANTED-AS-AGREED** (*Id*. at 149:15–150:9).

Plaintiff's MIL 14 **Any reference to the U.K. litigation.**

The MIL was **GRANTED**. (*Id*. at 148:4–149:14).

The Court noted that Previous Defendant's MIL 1 precludes references to evidence, arguments, verdicts, judgments, or orders from other litigations.

Plaintiff's MIL 15 **Any opinions regarding counting pages of the LTE specification, lines of code, or the number of declared patents.**

The MIL was **WITHDRAWN**. (*Id*. at 138:11–16).

Plaintiff's MIL 16 **Any reference to the price of non-accused devices without establishing technical comparability.**

The MIL was **DENIED**. (*Id*. at 144:22–145:19).

The Court ordered the parties to meet and confer regarding the use of non-accused devices in opening statements. The Court will take up any remaining disputes outside the presence of the jury.

Plaintiff's MIL 17 **Any allegation that Samsung copied Apple's design.**

The MIL was **GRANTED**. (*Id*. at 152:24–153:6).

The Court noted that there is an insufficient probative basis to discuss prior, settled disputes between Apple and Samsung related to design patents.

Plaintiff's MIL 18 **Previously granted or agreed-upon MILs.**

The MIL was **WITHDRAWN**. (*Id*. at 183:7–14).

## III. DEFENDANT'S MOTIONS *IN LIMINE* (Dkt. No. 633)

Defendant's MIL 1 **Any reference to the first trial, including the parties' arguments, the verdict, the result, and the now-vacated damages award.**

The MIL was **GRANTED-IN-PART** and **DENIED-IN-PART**. (*Id*. at 29:8–32:4).

The MIL was granted to the extent either party seeks to introduce evidence about the previous trial or publish the amount of damages awarded. The Court—not the parties—will instruct the jury as to what occurred in the previous trial with respect to infringement and invalidity. However, the Court's instruction will not be limited to merely instructing the jury to assume infringement and validity, and Apple's request to that effect was denied.

The Court noted that the sole issue in the upcoming trial is the appropriate FRAND royalty for the use of the standard-essential patents. The issues of infringement and validity have already been decided. Thus, Optis's request to introduce the prior statements of expert witnesses for impeachment purposes was denied.

<u>Defendant's MIL 2</u> **Any argument or evidence related to Plaintiffs' already-decided claims for infringement, validity, willfulness, enhanced damages, and/or declaratory judgment.**

The MIL was **GRANTED**. (*Id*. at 48:4–49:9).

The Court noted that after the bench trial held on August 11, 2020, the Court declined to exercise jurisdiction over Optis's claim for declaratory judgment (*See* Dkt. No. 538 at CL4, CL7) (declining to exercise jurisdiction over Count VIII of Optis's First Amended Complaint). Thus, Count VIII is not a live issue before the Court, and the Court does not intend to relitigate issues that were previously decided. The sole issue in the upcoming trial is the appropriate FRAND royalty for the use of the standard-essential patents.

<u>Defendant's MIL 3</u> **Derogatory remarks and arguments—e.g. that Apple is a holdout—calculated to inflame the jury to punish Apple.**

The MIL was **GRANTED**. (*Id*. at 61:7–62:5).

The Court noted that this evidence is irrelevant for the same reasons discussed with respect to Defendant's MIL 2. The Court also noted that the MIL is not intended to include or exclude particular exhibits, but rather is directed at elicited testimony and related argument on the excluded topic.

<u>Defendant's MIL 4</u> **Any reference to the parties' licensing negotiations and correspondence.**

The MIL was **DENIED**. (*Id*. at 74:15–77:13).

The Court noted that the jury must have an evidentiary basis to determine FRAND compliance of the competing royalty proposals, and to do so, the jury must hear evidence regarding

the parties' conduct in licensing discussions. The Court declined to limit the relevant time period of the parties' conduct to the hypothetical negotiation in 2012.

Defendant's MIL 5 **Any reference to Apple-Qualcomm negotiations, litigations, and agreements.**

The MIL was **DENIED**. (*Id*. at 95:2–15).

The Court noted that the MIL appears to be an effort to re-open pretrial motions practice with respect to *Daubert* and motions to strike. The experts must testify within the scope and content of their reports. They shall not testify otherwise.

Defendant's MIL 6 **Any evidence or argument that Plaintiffs could seek a larges damages award than $506.2 Million.**

The MIL was **GRANTED-IN-PART** and **DENIED-IN-PART**. (*Id*. at 109:11–16).

The Court denied the MIL as to evidence regarding the continued use of the accused technology from the time period of 2012 through August 11, 2020. The Court granted MIL as to any direct or indirect statement or inference that Optis could have collected damages for infringing activity before February 25, 2019.

Defendant's MIL 7 **Misleading and irrelevant LTE evidence and arguments.**

The MIL was **DENIED**. (*Id*. at 117:4–22).

Defendant's MIL 8 **Any evidence or argument referring to Apple's overall pricing of, or profits generated from, for cellular technology as a whole.**

The MIL was **DENIED**. (*Id*. at 117:23–118:14).

The Court noted that the experts will be allowed to testify consistent with the scope of their reports. They shall not testify otherwise.

Defendant's MIL 9 **Any evidence or argument referring to changes or lack of changes to the accused products.**

The MIL was **GRANTED-IN-PART** and **DENIED-IN-PART**. (*Id*. at 175:23–176:17).

The Court denied the MIL as to the time period from 2012 through August 11, 2020. The Court granted the MIL as to the time period from August 11, 2020 to the present.

Defendant's MIL 10 **Any argument or evidence concerning the absence of any Apple, Qualcomm, or Intel witness at trial.**

The MIL was **GRANTED-AS-AGREED**. (*Id*. at 183:15–24).

Defendant's MIL 11 **Any argument or evidence that third parties licensed Plaintiffs' portfolio because of the asserted patents.**

The MIL was **DENIED**. (*Id*. at 182:1–183:6).

However, notwithstanding the denial of the MIL, the parties are precluded from arguing that numerous companies took a license to Optis's portfolio, in an effort to suggest that the licenses were negotiated solely because of the patents-in-suit.

Defendant's MIL 12 **Any reference to evidence, arguments, verdicts, judgments, or orders from other litigations.**

In light of the Court re-entering all prior MIL rulings from the prior trial, the MIL was **DENIED AS MOOT**. (*Id*. at 145:20–146:12).

Defendant's MIL 13 **Irrelevant evidence about Apple's foreign operations.**

In light of the Court re-entering all previous MIL rulings from the previous trial, the MIL was **DENIED AS MOOT**. (*Id*. at 183:25–184:9).

Defendant's MIL 14 **Any argument or evidence about Apple's overall finances.**

In light of the Court re-entering all previous MIL rulings from the previous trial, the MIL was **WITHDRAWN**. (*Id*. at 118:15–119:4).

Defendant's MIL 15 **Any evidence about witness compensation unrelated to this case.**

In light of the Court re-entering all previous MIL rulings from the previous trial, the MIL was **DENIED AS MOOT**. (*Id*. at 183:25–184:9).

Defendant's MIL 16 **Any argument or evidence about Steve Jobs, political positions taken by Apple or its leadership, and media reports unrelated to this litigation.**

In light of the Court re-entering all previous MIL rulings from the previous trial, the MIL was **DENIED AS MOOT**. (*Id*. at 183:25–184:9).

Defendant's MIL 17 **Any reference to innography "strength scores"**

The MIL was **DENIED**. (*Id*. at 130:16–131:14).

However, the Court noted that the MIL appears to be an effort to re-open pretrial motions practice with respect to *Daubert* and motions to strike. The experts must testify within the scope and content of their reports. They shall not testify otherwise.

Defendant's MIL 18 **Permit Apple to refer to Optis's' United Kingdom claims if Optis falsely suggests the retrial is the sole means by which Optis is pursuing royalties.**

The MIL was **DENIED**. (*Id*. at 148:4–149:9).

The Court noted that requested relief is premature in view of the stage of the United Kingdom litigation, and in any event, Previous Defendant's MIL 1 precludes references to evidence, arguments, verdicts, judgments, or orders from other litigations.

**So ORDERED and SIGNED this 9th day of August, 2021.**

Rodney Gilstrap

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC., et al, | ( | CAUSE NO. 2:19-CV-066-JRG |
| Plaintiffs, | ) | |
| | ( | |
| vs. | ) | |
| | ( | |
| APPLE, INC., | ) | AUGUST 10, 2021 |
| | ( | MARSHALL, TEXAS |
| Defendant. | ) | 9:00 A.M. |

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VOLUME 1

---

TRIAL ON THE MERITS

BEFORE THE HONORABLE RODNEY GILSTRAP
UNITED STATES CHIEF DISTRICT JUDGE
and a jury

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A P P E A R A N C E S

| | |
|---|---|
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| | McKOOL SMITH, P.C. - MARSHALL<br>104 EAST HOUSTON ST., STE. 300<br>MARSHALL, TEXAS 75670<br>(903) 923-9000<br>BY: MS. JENNIFER TRUELOVE<br>MR. SAM BAXTER |
| FOR DEFENDANT: | WILMER HALE - BOSTON<br>60 STATE STREET<br>BOSTON, MA 02109<br>(617) 526-6000<br>BY: MR. JOSEPH MUELLER |
| | GILLAM & SMITH, LLP<br>303 SOUTH WASHINGTON AVENUE<br>MARSHALL, TEXAS 75670<br>(903) 934-8450<br>BY: MS. MELISSA SMITH |
| OFFICIAL REPORTER: | SHAWN M. McROBERTS, RMR, CRR<br>100 E. HOUSTON STREET<br>MARSHALL, TEXAS 75670<br>(903) 923-7464 |

Counsel, based on our discussions in chambers, I understand there are one or two matters you'd like to bring up with the Court before I bring in the jury.

Let me hear from you at this time.

MR. SHEASBY: Jason Sheasby for the Plaintiffs, Your Honor. Plaintiffs would like confirmation the Court has ruled that negotiation history can come in in front of the jury and has withdrawn its MIL on that subject.

THE COURT: That's my understanding. Does Defendant have anything different on that?

MR. MUELLER: Joe Mueller for the Defendant, Your Honor.

That's correct. We understand that to be Your Honor's ruling. And so I think the parties are in agreement that Your Honor has so ruled.

And if I could, Your Honor, if I could just take a moment to just very briefly preserve our own positions on these issues. We've done our best to memorialize in Docket No. 666 various rulings that Your Honor has made on issues in this case, including over the last couple of days.

We don't want to keep getting up to interrupt the proceedings, Your Honor. So we respectfully request the running objection with respect to those issues, for example, the admissibility of the Qualcomm agreement. So we respectfully request that that standing running objection as

opposed to interrupting the proceedings, Your Honor.

THE COURT: I have no problem with the Defendants having a running objection as outlined.

MR. MUELLER: Thank you, Your Honor. The final issue is just, we understood, I just wanted to state on the record, that your *Daubert* rulings are definitive. We will, of course, strictly comply with them, and we understand that we do not need to repeatedly object to the relevant expert opinions that were briefed in *Daubert*.

THE COURT: That is my understanding, and that is certainly my preference. I want as few interruptions or disruptions during the trial as possible, and at the same time I don't intend to be an impediment to anybody preserving a point that they believe they need to be preserved.

MR. MUELLER: Thank you, Your Honor.

Finally, Mr. Sheasby and I conferred on the break that we think, again, in the interest of avoiding interrupting the proceedings, that we should seal the opening statements. There's going to be some discussion of license negotiations and certain agreements. That has not only confidential information of the parties but certain third parties. And so we would ask that the opening statements be sealed.

For Mr. Sheasby's opening statement, I believe he's going to get into some information that Mr. Blasius cannot see. It's third-party confidential. Mr. Blasius can see my entire

often require members to license to others to use standard essential patents on these RAND, reasonable and nondiscriminatory, terms. Sometimes these terms are also referred to as FRAND, fair, reasonable, and nondiscriminatory. And I'll give you more detailed instructions on these matters at the end of the trial.

Now, ladies and gentlemen, I know that there are a lot of new words and new concepts that have been thrown at you since you arrived here for jury duty this morning. I'm going to define a lot of these words and concepts for you as we go through my instructions. The attorneys are going to discuss them with you in their opening statements. The witnesses are going to help you through their testimony to understand these concepts and terms.

So, please, do not feel overwhelmed at this point. I promise you it will all come together as we go through the trial.

Now, your job in this case is to decide what amount of money damages, if any, to be awarded to the Plaintiffs as compensation for the infringement of their five patents. My job in this case is to tell you what the law is, handle rulings on evidence and procedure, and to oversee the trial as efficiently and effectively as possible.

In deciding the issues that are before you, you will be asked to consider specifically the rules, and I'll give you an

I HEREBY CERTIFY THAT THE FOREGOING IS A CORRECT TRANSCRIPT FROM THE RECORD OF PROCEEDINGS IN THE ABOVE-ENTITLED MATTER. I FURTHER CERTIFY THAT THE TRANSCRIPT FEES FORMAT COMPLY WITH THOSE PRESCRIBED BY THE COURT AND THE JUDICIAL CONFERENCE OF THE UNITED STATES.

S/Shawn McRoberts 08/10/2021

__________________________DATE____________
SHAWN McROBERTS, RMR, CRR
FEDERAL OFFICIAL COURT REPORTER

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC., et al, Plaintiffs, | ( ) ( ) | CAUSE NO. 2:19-CV-066-JRG |
| vs. | ( ) | |
| APPLE, INC., Defendant. | ( ) ( | AUGUST 11, 2021 MARSHALL, TEXAS 8:30 A.M. |

VOLUME 2

TRIAL ON THE MERITS

BEFORE THE HONORABLE RODNEY GILSTRAP
UNITED STATES CHIEF DISTRICT JUDGE
and a jury

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MR. MUELLER: I object, Your Honor.

THE COURT: What's your objection, counsel?

MR. MUELLER: Your Honor, this again is characterizing the company as a whole in comparison to Samsung as a whole without any effort to tie numbers that are being discussed to the particular patents at issue, Your Honor.

THE COURT: I don't think anybody would dispute and I don't think it's improper testimony for the witness to establish that Apple is a large company, but I'm not going to permit precise testimony about profits and stock price and capitalization as to the entirety of Apple, Inc.

But the profits and the income related to the accused devices directly relate to what a fair, reasonable, and nondiscriminatory royalty would be, and that's permitted and that's the line I'm trying to draw. I don't believe that the question crosses that line. Therefore, I'm going to overrule your objection.

MR. MUELLER: Thank you, Your Honor.

THE COURT: Let's proceed, Mr. Baxter.

MR. BAXTER: Yes, Your Honor.

Q. (BY MR. BAXTER) Do you know Doctor Perryman?

A. Yes.

Q. He's going to testify sometime in this case as a damage expert for Apple, is he not?

A. Yes, I believe so.

I HEREBY CERTIFY THAT THE FOREGOING IS A CORRECT TRANSCRIPT FROM THE RECORD OF PROCEEDINGS IN THE ABOVE-ENTITLED MATTER. I FURTHER CERTIFY THAT THE TRANSCRIPT FEES FORMAT COMPLY WITH THOSE PRESCRIBED BY THE COURT AND THE JUDICIAL CONFERENCE OF THE UNITED STATES.

S/Shawn McRoberts 08/10/2021

__________________________DATE____________
SHAWN McROBERTS, RMR, CRR
FEDERAL OFFICIAL COURT REPORTER

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC., et al, | ( ) | CAUSE NO. 2:19-CV-066-JRG |
| Plaintiffs, | ( ) | |
| vs. | ( ) | |
| APPLE, INC., | ( ) | AUGUST 13, 2021 MARSHALL, TEXAS |
| Defendant. | ( | 8:30 A.M. |

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VOLUME 4

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TRIAL ON THE MERITS

BEFORE THE HONORABLE RODNEY GILSTRAP
UNITED STATES CHIEF DISTRICT JUDGE
and a jury

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regardless of who may have introduced them.

Now, as I did at the beginning of the case, I'll first give you a summary of Optis' contentions in this case. I'll then provide you with detailed instructions on what Optis, the Plaintiffs, must prove to win on each of their contentions.

As I previously told you, this is a case to set a fair, reasonable, and nondiscriminatory damages award for patent infringement by Apple, Inc., who I'll refer to simply as Apple or as the Defendant.

Remember, ladies and gentlemen, there are five Patents-in-Suit, and they are United States Patent No. 8,019,332, which you've heard referred to simply as the '332 Patent; United States Patent No. 8,385,284, which you've heard referred to as the '284 Patent; United States Patent 8,411,557, which you've heard referred to as the '557 Patent; United States Patent No. 8,102,833, which you've heard referred to as the '833 patent; and United States Patent No. 9,001,774, which you've heard referred to as the '774 Patent. And you've also heard these patents and I will refer to these patents collectively as the Patents-in-Suit or as the asserted patents.

Now, it has been determined that certain of Apple's iPhones, iPads, and Apple Watches infringe the asserted patents. Sometimes in these instructions, I'll refer to these products by shorthand as simply the accused products.

The claims at issue in this case are claims 6 and 7 of the '332 Patent; claims 1, 14, and 27 of the '284 Patent; claims 1 and 10 of the '557 Patent; claim 6 of the '774 Patent; and claim 8 of the '833 patent. It has already been determined that these claims are not invalid.

Now, your job in this case is solely to determine the amount of money damages, if any, to be awarded to Optis as compensation for the infringement of the Patents-in-Suit. The damages period in this case, ladies and gentlemen, begins on the date the complaint was filed, which is February the 25th, 2019, and it runs through August the 3rd, 2020.

I'll now instruct you about the measure of damages. Optis, the Plaintiffs, have the burden to establish the amount of their damages by a preponderance of the evidence. In other words, you should only award those damages that Optis establishes are more likely than not fair, reasonable, and nondiscriminatory compensation. While Optis is not required to prove the amount of its damages with mathematical precision, it must prove them with reasonable certainty. Optis is not entitled to damages that are remote or that are only speculative.

The damages award must be adequate to compensate for the infringement. You must not award Optis more damages than are adequate to compensate for the infringement. You also must not include any additional amount for the purposes of

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S/Shawn McRoberts 08/13/2021

____________________________DATE_____________
SHAWN McROBERTS, RMR, CRR
FEDERAL OFFICIAL COURT REPORTER

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § § § § § § | |
| *Plaintiffs*, | § § § | |
| v. | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| APPLE INC., | § § § | |
| *Defendant*. | § | |

# VERDICT FORM

In answering the following questions and completing this Verdict Form, you are to follow all the instructions I have given you in the Court's Final Jury Instructions. Your answers to each question must be unanimous. Some of the questions contain legal terms that are defined and explained in detail in the Final Jury Instructions. You should refer to and consider the Final Jury Instructions as you answer the questions in this Verdict Form.

As used herein, the following terms have the following meanings:

- "Optis" refers collectively to Optis Wireless Technology, LLC; Optis Cellular Technology, LLC; Unwired Planet, LLC; PanOptis Patent Management, LLC; and Unwired Planet International Limited.
- "Apple" refers to Apple Inc.
- A "FRAND" royalty refers to a fair, reasonable, and non-discriminatory royalty.

**IT IS VERY IMPORTANT THAT YOU FOLLOW THE INSTRUCTIONS PROVIDED IN THIS VERDICT FORM.**

**READ THEM CAREFULLY AND ENSURE YOUR VERDICT COMPLIES WITH THEM.**

**YOU SHOULD ANSWER BOTH QUESTIONS 1A AND 1B.**

**QUESTION NO. 1a:**

What sum of money, if any, paid by Apple now in cash, has Optis proven by a preponderance of the evidence would compensate Optis as a FRAND royalty for the damages resulting from infringement between February 25, 2019 and August 3, 2020?

Answer in United States Dollars and Cents, if any:

$ 300,000,000.00

**QUESTION NO. 1b:**

Is the total amount you found in Question No. 1a a lump-sum for past and future sales or is it a running royalty for past sales only?

Check **one** of the following:

**Lump-sum** ✓

**—OR—**

**Running Royalty** ______

## FINAL PAGE OF JURY VERDICT FORM

You have now reached the end of the Verdict Form and should review it to ensure it accurately reflects your **unanimous** determinations. The Jury Foreperson should then sign and date the Verdict Form in the spaces below. Once this is done, notify the Court Security Officer that you have reached a verdict. The Jury Foreperson should keep the Verdict Form and bring it when the jury is brought back into the courtroom.

Signed this 13 day of August, 2021.

________________________________
Jury Foreperson

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § | |
| *Plaintiffs*, | § | |
| v. | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| APPLE INC., | § | |
| *Defendant*. | § | |

**FINAL JUDGMENT**

Pursuant to the Court's previous Order (Dkt. No. 585), a second jury trial commenced in this case on August 10, 2021 solely addressing the topic of damages relating to the infringement of U.S. Patent Nos. 8,019,332 (the "'332 Patent"), 8,385,284 (the "'284 Patent"), 8,411,557 (the "'557 Patent"); 8,102,833 (the "'833 Patent"), and 9,001,774 (the "'774 Patent") (collectively, the "Asserted Patents"). On August 13, 2021, the jury returned a unanimous verdict finding that Plaintiffs Optis Wireless Technology, LLC, PanOptis Patent Management, LLC, Optis Cellular Technology, LLC, Unwired Planet, LLC, and Unwired Planet International Limited ("Optis") are owed a reasonable royalty of $300,000,000.00 in the form of a lump-sum for the previously established infringement of the Asserted Patents by Apple Inc. ("Apple"). (Dkt. No. 684).

Pursuant to Rule 58 of the Federal Rules of Civil Procedure, and in accordance with the jury's unanimous verdict and the entirety of the record, the Court hereby **ORDERS** and **ENTERS JUDGMENT** as follows:

1. The Court fully adopts and makes a part hereof the portions of the previous Judgment (Dkt. No. 544) which were not expressly vacated as a part of the Court's prior Order (Dkt. No. 585), to-wit:

A. Apple has infringed one or more of the Asserted Claims;[1]

B. The Asserted Claims are not invalid;

C. Apple's infringement was willful;

D. Notwithstanding the jury's finding of willfulness, the Court having considered the totality of the circumstances together with the added material benefit of having presided throughout the jury trial and having seen both the same evidence and heard the same arguments as the jury, and mindful that enhancement is generally reserved for "egregious cases of culpable behavior,"[2] concludes that enhancement of the compensatory award herein is not warranted under 35 U.S.C. § 284 and consequently, the Court elects not to enhance the damages awarded herein;

E. Pursuant to 35 U.S.C. § 284 and Supreme Court guidance that "prejudgment interest shall ordinarily be awarded absent some justification for withholding such an award,"[3] the Court awards pre-judgment interest applicable to all sums awarded herein, calculated at the 5-year U.S. Treasury Bill rate, compounded quarterly, from the date of infringement through the date of entry of this Judgment;[4] and

---

[1] The Asserted Claims are claims 6 and 7 of the '332 Patent; claims 1, 14, and 27 of the '284 Patent; claims 1 and 10 of the '557 Patent; claim 6 of the '774 Patent; and claim 8 of the '833 Patent.
[2] *Halo Electronics, Inc. v. Pulse Electronics, Inc.*, 136 S.Ct. 1923, 1934 (2016).
[3] *General Motors Corp. v. Devex Corp.*, 461 U.S. 648, 657 (1983).
[4] *See Nickson Indus., Inc. v. Rol Mfg. Co., Ltd.*, 847 F.2d 795, 800–801 (Fed. Cir. 1988).

F. Pursuant to 28 U.S.C. § 1961, the Court awards post-judgment interest applicable to all sums awarded herein, at the statutory rate, from the date of entry of this Judgment until paid.

2. Optis is hereby awarded damages against Apple and shall accordingly recover from Apple the sum of $300,000,000.00 U.S. Dollars as a lump-sum for past and future sales.

3. Pursuant to Federal Rule of Civil Procedure 54(d), Local Rule CV-54, and 28 U.S.C. § 1920, Optis is the prevailing party in this case and shall recover its costs from Apple. Optis is directed to file its proposed Bill of Costs.

All other requests for relief now pending and requested by either party but not specifically addressed herein are **DENIED**.

**So ORDERED and SIGNED this 8th day of September, 2021.**

Rodney Gilstrap

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF TEXAS**
**MARSHALL DIVISION**

| | | |
|---|---|---|
| OPTIS WIRELESS TECHNOLOGY, LLC, OPTIS CELLULAR TECHNOLOGY, LLC, PANOPTIS PATENT MANAGEMENT, LLC, UNWIRED PLANET, LLC, UNWIRED PLANET INTERNATIONAL LIMITED, | § | |
| *Plaintiffs*, | § | CIVIL ACTION NO. 2:19-CV-00066-JRG |
| v. | § | |
| APPLE INC., | § | |
| *Defendant*. | § | |

**ORDER**

Before the Court is Defendant Apple Inc.'s ("Apple") Motion for a New Trial (the "New Trial Motion") (Dkt. No. 699) and Apple's Rule 50(b) (Motion for Judgment as a Matter of Law (the "JMOL Motion") (Dkt. No. 700). Having considered the New Trial Motion and the JMOL Motion, and for the reasons stated herein, the Court finds that both should be **DENIED**.

## I. BACKGROUND

Plaintiffs Optis Wireless Technology, LLC, Optis Cellular Technology, LLC, PanOptis Patent Management, LLC, Unwired Planet, LLC, and Unwired Planet International Limited (collectively, "Optis") filed the above-captioned case against Apple on February 25, 2019, asserting infringement of seven patents. (Dkt. No. 1, ¶ 1.) Prior to trial, two of the asserted patents were dropped by Optis. The Court conducted a jury trial with respect to the remaining five patents (U.S. Patent Nos. 8,019,332, 8,385,284, 8,411,557, 9,001,774, and 8,102,833 (collectively, the "Asserted Patents" or "patents-in-suit")) from August 3, 2020 through August 11, 2020. (Dkt. Nos.

460, 461, 466, 474, 482, 485, 486.) On August 11, 2020, the jury returned a verdict that Apple willfully infringed certain claims of the Asserted Patents. (Dkt. No. 483.) The jury awarded $506,200,000 as a reasonable royalty for such infringement. (*Id.*) The jury also found such to be a running royalty. (*Id.*) The Court entered a Final Judgment on February 25, 2021, memorializing the jury's findings but electing not to enhance damages for willful infringement under 35 U.S.C. § 284. (Dkt. No. 544.)

Apple subsequently moved for a new trial because it alleged that the jury did not hear evidence regarding Optis's obligation to license the patents on fair, reasonable, and nondiscriminatory ("FRAND") terms. (Dkt. No. 549 at 9.) The jury's verdict, Apple argued, was thus not compliant with FRAND terms and was in violation of the FRAND limitations on reasonably royalty awards for standard essential patents. (*Id.* at 13–14.) Apple contended that at a minimum, damages should be retried, while maintaining that a new trial regarding all issues was appropriate given that the exclusion of FRAND "had prejudicial effects that went beyond damages." (*Id.* at 15.) Apple further argued that by failing to plead an affirmative FRAND counterclaim or defense, it did not waive its right to challenge the verdict as not being FRAND-compliant. (*Id.* at 15–19.)

On April 14, 2021, the Court granted a new trial as to damages in the above-captioned case, vacating the Court's previous Judgment as to damages. (Dkt. Nos. 544, 585.) The Court found that a new trial on damages was warranted as to the amount of a FRAND royalty for the use of the Asserted Patents. (Dkt. No. 585 at 9.) The Court declined, however, to grant a new trial as to other issues, including liability. (*Id.* at 10.)

In the subsequent jury trial regarding damages, the jury found that Optis proved by a preponderance of the evidence that a lump-sum (as opposed to a running royalty) of $300 million

"would compensate Optis as a FRAND royalty for the damages resulting from infringement between February 25, 2019 and August 3, 2020." (Dkt. No. 684 at 4–5.) Apple moved for Judgment as a Matter of Law ("JMOL") under Rule 50(a), arguing that Optis failed to present sufficient evidence to support a damages award. (Dkt. No. 682.) Apple filed the instant motions on October 6, 2021. (*See generally* Dkt. Nos. 699–700.)

## II. Legal Standard

### a. Judgment as a Matter of Law

"Judgment as a matter of law is proper when 'a reasonable jury would not have a legally sufficient evidentiary basis to find for the party on that issue.'" *Abraham v. Alpha Chi Omega*, 708 F.3d 614, 620 (5th Cir. 2013) (quoting Fed. R. Civ. P. 50(a)). The non-moving party must identify "substantial evidence" to support its positions. *TGIP, Inc. v. AT&T Corp.*, 527 F. Supp. 2d 561, 569 (E.D. Tex. 2007). "Substantial evidence is more than a mere scintilla. It means such relevant evidence as a reasonable mind might accept as adequate to support a conclusion." *Eli Lilly & Co. v. Aradigm Corp.*, 376 F.3d 1352, 1363 (Fed. Cir. 2004).

"The Fifth Circuit views all evidence in a light most favorable to the verdict and will reverse a jury's verdict only if the evidence points so overwhelmingly in favor of one party that reasonable jurors could not arrive at any contrary conclusion." *Core Wireless Licensing S.A.R.L. v. LG Elecs., Inc.*, 880 F.3d 1356, 1361 (Fed. Cir. 2018) (citing *Bagby Elevator Co. v. Schindler Elevator Corp.*, 609 F.3d 768, 773 (5th Cir. 2010)). A court must "resolve all conflicting evidence in favor of [the verdict] and refrain from weighing the evidence or making credibility determinations." *Gomez v. St. Jude Med. Daig Div. Inc.*, 442 F.3d 919, 937–38 (5th Cir. 2006).

**b. New Trial**

Rule 59 provides that a new trial may be granted on all or part of the issues on which there has been a trial by jury for "any reason for which a new trial has heretofore been granted in an action at law in federal court." Fed. R. Civ. P. 59(a). Notwithstanding the broad sweep of Rule 59, "courts do not grant new trials unless it is reasonably clear that prejudicial error has crept into the record or that substantial justice has not been done, and the burden of showing harmful error rests on the party seeking the new trial." *Metaswitch Networks Ltd. v. Genband US LLC*, 2017 WL 3704760, at *2 (E.D. Tex. Aug. 28, 2017); *Erfindergemeinschaft UroPep GbR v. Eli Lilly & Co.*, 276 F. Supp. 3d 629, 643 (E.D. Tex. 2017). "A new trial may be granted, for example, if the district court finds the verdict is against the weight of the evidence, the damages awarded are excessive, the trial was unfair, or prejudicial error was committed in its course." *Smith v. Transworld Drilling Co.*, 773 F.2d 610, 612–13 (5th Cir. 1985); *see also Laxton v. Gap Inc.*, 333 F.3d 572, 586 (5th Cir. 2003) ("A new trial is warranted if the evidence is against the great, and not merely the greater, weight of the evidence."). Furthermore "[u]nless justice requires otherwise, no error in admitting or excluding evidence—or any other error by the court or a party—is ground for granting a new trial . . . the court must disregard all errors and defects that do not affect any party's substantial rights." Fed. R. Civ. P. 61.

**III. Discussion**

Under Federal Rule of Civil Procedure 50(b), Apple filed a JMOL Motion seeking judgment as a matter of law that Optis failed to present sufficient evidence to support the verdict. (Dkt. No. 700.) Apple also moves for a new trial on substantially the same grounds. (Dkt. No. 699.) The Court finds that substantial evidence exists supporting the jury's damages verdict on

each of the grounds raised by Apple, and none of those grounds compel setting aside the jury's verdict and granting a new trial.

Many of the grounds that Apple asserts in its New Trial Motion are identical to those asserted in Apple's JMOL Motion. (*See generally* Dkt. Nos. 699, 700.) Accordingly, where appropriate, the Court addresses those arguments together.

#### *i. JMOL and New Trial: Infringement Finding in Verdict Form*

The verdict form in the first trial was not broken down by patent or claim and instead asked if Apple infringed "any" of the asserted claims. (Dkt. No. 699 at 1; Dkt. No. 700 at 1.) Based on this, Apple contends that the record does not support an assumption that the prior jury agreed that Apple infringed *any* particular claim, "much less all asserted claims." (Dkt. No. 700 at 1.) Apple also contends that, in the first trial, both parties submitted proposed verdict forms that broke the infringement question down by patent or claim, but the Court used its own language. (*Id*. at n.1.) In the damages retrial, Apple alleges that Optis presented a damages theory which assumed infringement of *every* asserted claim of *every* asserted patent. (*Id*. at 2.) Therefore, Apple argues that the jury's damages award was not attributed to particular claims and thus that Optis has "sought and been awarded damages for a scope of infringement that they have not proven and that no jury has unanimously found." (*Id*.) Apple further argued that JMOL of no damages is warranted "for the additional reason that Plaintiffs seek to obtain a FRAND royalty in concurrent litigation in the United Kingdom for the same five patents asserted in this litigation." (*Id*.)

In response, Optis contends that the Court has already rejected Apple's argument regarding the verdict form after the first jury returned "the exact amount [Optis] sought for infringement of each of the patents-in-suit." (Dkt. No. 707 at 1 (citing Dkt. No. 667 at 32–33).) Optis argues that Apple itself proposed that the jury be instructed to assume "infringement of all of the asserted

claims" and not just "one or more claims" as it now suggests, thus waiving any argument to the contrary. (Dkt. No. 706 at 1; Dkt. No. 707 at 1.) Optis contends that its experts expressly testified as to their opinions regarding which claims of which patents were infringed. (Dkt. No. 707 at 1.) According to Optis, its damages expert, Mr. Kennedy, explained his damages calculation on a patent-by-patent basis. (*Id*. at 2.) Further, Optis contends that "even if Apple infringed just the single asserted claim" of *one* of the patents, the $300 million verdict would have had substantial evidentiary support. (Dkt. No. 706 at 1.) Optis finally argues that the "double recovery" theory posited about the proceedings in the UK was waived by Apple, who did not "bring[] an affirmative defense or counterclaim at any point in this case despite the fact the UK litigation was filed on the same day as the present action." (Dkt. No. 707 at 1.)

Apple contends that it objected to the verdict form at the previous trial, in its previous post-trial briefing, before the retrial jury charge, and in its Rule 50(a) motion, arguing that the Court granted Apple a running objection on the issue but ultimately rejected Apple's objection. (Dkt. No. 710 at 1; Dkt. No. 711 at 1.) Apple further argues that Optis cannot rely on the prior jury's award of the full damages ask for infringement because that award was vacated, and the sufficiency of the damages award in this case needed to be based on an explicit liability finding for each patent. (Dkt. No. 710 at 1.) As to the issue of the UK litigation, Apple argues that there is no basis for the notion that it was required to plead double recovery as an affirmative defense, and contends that "Plaintiffs do not deny that they seek double recovery" based on the UK litigation. (Dkt. No. 711 at 1.)

Optis replies that the various objections that Apple made to the verdict form "have nothing to do with the question of whether there was evidence of infringement of the patents." (Dkt. No. 717 at 1.) Rather, Optis contends that those objections were directed at language different from

the language now in dispute. (*Id.*) Optis also argues that Apple "does not deny that its proposed jury instruction [was] substantially the same one as it now challenges." (*Id.*)

The Court finds no error in the language of the verdict form that would undermine the jury's verdict or necessitate a new trial. Apple's own proposed jury instructions stated that the jury was to "assume" that the "patents-in-suit are valid and infringed." (Dkt. No. 706 at 1 (citing Dkt. No. 677 at 11, 22).) Based on that instruction, Optis's experts opined that all asserted claims of all asserted patents were infringed and attributed damages awards to each patent. (*See, e.g.*, Dkt. No. 691 at 236:10–14, 249:14–16; *see also, e.g.*, Dkt. No. 692 at 16:5–10, 28:2–6, 35:9–12, 181:21–25.) Accordingly, the record contained sufficient evidence of infringement consistent with the jury's damages award. Moreover, the instruction the jury ultimately heard is substantially equivalent to the instruction proposed by Apple. Finally, as to Apple's argument regarding the UK FRAND litigation, the Court is not persuaded that the existence of a co-pending litigation in another country warrants JMOL or a new trial in the case at bar.

***ii. JMOL and New Trial: Mr. Kennedy's Infrastructure Approach***

Apple argues that Mr. Kennedy's "infrastructure approach" rested on the "unsupported assumption that Apple would pay network carriers to compensate for the inefficiencies the Apple products would allegedly suffer without using the asserted patents" and was thus speculative. (Dkt. No. 699 at 5; Dkt. No. 700 at 3.) According to Apple, Mr. Kennedy "admitted" in a prior proceeding that such an approach was "not economically feasible" and did not address the feasibility issue in this case by speaking to anyone at a network carrier to confirm that it "could compensate for degraded LTE speed in phones by adding network capacity." (Dkt. No. 700 at 3; *see also* Dkt. No. 699 at 5.) Apple also maintains that Mr. Kennedy could not point to any instance in which such a payment occurred between a phone supplier and a carrier and alleges that a

different expert showed the opposite—that investing a dollar into improving LTE infrastructure would not yield a dollar improvement in upload or download speed. (Dkt. No. 700 at 4; *see also* Dkt. No. 699 at 6.) Similarly, Apple argued that the jury did not hear about any relationship between infrastructure expenditure and network speed of mobile devices, and instead heard the contradicting testimony from a different expert. (*Id*.) Apple argues that "by relying on the price of network equipment to calculate his royalty, as opposed to the accused functionality in the accused devices, Mr. Kennedy failed to apportion his damages demand to the value of the claimed inventions." (*Id*. at 5.) Apple finally contends that Mr. Kennedy was previously barred from offering the "same" theory against Apple in the Southern District of California because it was too speculative. (*Id*.)

Optis argues that Apple's argument is an "improper attack[] on methodology" that was raised and rejected at the *Daubert* stage. (Dkt. No. 707 at 2–4; *see also* Dkt. No. 706 at 4–5.) Optis cites to testimony and exhibits that it contends "showed that investment in LTE speed-specific infrastructure assets can compensate for a degradation in speed," including testimony by Mr. Kennedy. (Dkt. No. 707 at 5.) Optis also argues that Apple provides "no support" for the argument that Mr. Kennedy needed to determine the amount of "unused US network capacity" or that he needed to speak to a network carrier. (Dkt. No. 706 at 5.) Optis alleges that Mr. Kennedy "proceeded with apportionment in percentage terms based on the LTE speed of the accused products relative to the next-best non-infringing alternatives . . . determined" by Optis's technical experts, Dr. Madisetti and Dr. Mahon. (Dkt. No. 707 at 6.) Accordingly, Optis contends that Mr. Kennedy's infrastructure approach "analyzed the incremental cost of providing the bandwidth that was otherwise saved by using the infringing technology" and that the "additional network infrastructure" was simply a means by which Apple could "offset the lost speed if it could not use"

the asserted patents, "and thus [was] a way of measuring the value of the patents to Apple." (*Id*. at 6–7.) Optis further contends that Dr. Madisetti testified that the impact of the asserted patents was "directly related to quality of service." (*Id*. at 7.) Optis also argues that the record contained evidence that the infrastructure approach is used in the real world. (*Id*.) Specifically, Optis maintains that Apple does not dispute that [redacted] and noted that expert testimony showed that such payments did occur in the real world. (Dkt. No. 706 at 5.)

Apple first responds that a "challenge to sufficiency of evidence" to support a verdict is "separate from a *Daubert* challenge." (Dkt. No. 711 at 2.) Apple also argues that Optis's briefing does not address the "fundamental flaws" in Mr. Kennedy's infrastructure approach, including that he "never investigated whether additional network equipment would even be necessary" and that he relied on testimony from Dr. Mahon and Dr. Madisetti "regarding a relationship between speed and network capacity" without addressing the "need for additional capacity." (*Id*.) Apple contends that Mr. Kennedy needed to determine, for example, unused network capacity and speak to technical experts to support his "assumption that Apple would pay to build new infrastructure." (Dkt. No. 710 at 2.) Apple further argues that there is "no evidence" that Apple "views the purchase of dedicated network capacity as an alternative tool" for achieving higher network speeds, and Apple argues that the jury was not permitted to disregard allegedly "uncontradicted" testimony from an Apple employee, Mr. Blevins, that [redacted] never occurred. (Dkt. No. 711 at 3.) Apple separately argues that Mr. Kennedy did not properly apportion his analysis because his baseline number for "LTE 'radio assets'" allegedly includes thousands of other LTE patents. (Dkt. No. 710 at 2.)

In response, Optis contends that Apple does not dispute that it is raising the same arguments that were rejected at the *Daubert* stage and argues that all of Apple's arguments go to whether Mr. Kennedy used an appropriate methodology, not to the sufficiency of the evidence. (Dkt. No. 716 at 1.) Optis also argues that Apple's post-trial attorney argument on the use of additional network equipment cannot overcome unrebutted testimony of Optis's experts at trial. (*Id*. at 2–3.) Optis argues that Mr. Kennedy's assumption that Apple would [redacted] was "corroborated by Apple's own internal documents." (Dkt. No. 717 at 2.) Optis also points to evidence that showed [redacted], thus contradicting testimony from Mr. Blevins that Apple says was "uncontested." (Dkt. No. 716 at 3.) Further, Optis contends that there was substantial evidence to show that Mr. Kennedy, relying on opinions from Dr. Mahon and Dr. Madisetti, apportioned down from his baseline to account for the "incremental benefit added by each patent," and that Apple had the opportunity to cross-examine Mr. Kennedy on the same. (Dkt. No. 717 at 2–3.)

The Court finds that Apple's attack on Mr. Kennedy's infrastructure approach was already rejected by the Court at the *Daubert* stage. (*See* Dkt. No. 438 at 27:23–28:11.) There, the Court found that Mr. Kennedy's infrastructure approach was best "addressed by cross-examination" rather than by outright exclusion. (*Id*.) The jury was tasked with "[w]eighing the conflicting evidence and the inferences to be drawn from that evidence[] and determining the relative credibility of the witness[.]" *Innovation Scis. LLC v. Amazon.com, Inc*., 2021 WL 2075677, at *2 (E.D. Tex. May 24, 2021). At trial, the jury heard evidence that Apple contends "conflicted" with Mr. Kennedy's testimony (*see, e.g*., Dkt. No. 700 at 4–5) and they weighed such "allegedly inconsistent evidence" in accordance with the law. *i4i Ltd. P'ship v. Microsoft Corp*., 598 F.3d

831, 849 (Fed. Cir. 2010), *aff'd*, 564 U.S. 91 (2011). Thus, Apple's arguments, insofar as they relate to the reliability of Mr. Kennedy's methodology, are rejected and do not warrant the relief Apple seeks. *Versata Software Inc. v. SAP America Inc.*, 717 F.3d 1255, 1264 (Fed. Cir. 2013).

***iii. JMOL and New Trial: Mr. Kennedy's Survey Approach***

Apple contends that Mr. Kennedy's reliance on Dr. Reed-Arthurs's survey, which "theorized that a speed increase (which [was] attributed 100% to the asserted patents) would lead to a price increase," was flawed and should have been excluded because her calculation of earned profits was "divorced from the record and reality." (Dkt. No. 699 at 6; Dkt. No. 700 at 6.) Apple argues that Dr. Reed-Arthurs's underlying survey—which posited that consumers would be willing to pay for a finite increase in LTE speed—was incorrect because it conflicted with "real-world evidence" that Apple's products did not change price with changes in LTE speeds. (Dkt. No. 700 at 6–7.) Apple also argues that Dr. Reed-Arthurs's survey evaluated "hypothetical products" and relied on "flawed" testing by others. (*Id*. at 7.) Finally, Apple argues that Dr. Reed-Arthurs "admitted that she had never used the type of survey she conducted . . . to value patents outside of litigation." (*Id*.)

Optis believes Apple's argument is an attempted post-trial *Daubert* attack on Optis's methodology. (Dkt. No. 706 at 5.) Optis maintains that Mr. Kennedy's survey approach was an "independent source" of substantial evidence to support the verdict as an alternative to his infrastructure approach. (Dkt. No. 707 at 10–11.) Optis also notes that Apple has previously used the same type of survey it now criticizes. (Dkt. No. 706 at 5.) Optis states that the Court has previously held that a general verdict will be upheld if there is sufficient evidence to support *any* of the factual theories of the case. (Dkt. No. 707 at 11.) Optis contends that the evidence "demonstrates that Apple priced its faster iPhones high[er] than its slower iPhones" and that

Apple's customers place "value" on an increase in connectivity speed. (*Id*. at 11–12; *see also* Dkt. No. 706 at 6.) Optis states that Mr. Kennedy's infrastructure approach yielded an apportioned value of $7.99 per phone, and the survey approach resulted in an apportioned value of $8.49 per phone. (Dkt. No. 707 at 11–12.) Accordingly, the jury was free to credit either approach, and they were also free to credit (or not credit) Dr. Reed-Arthurs's testimony about the pricing methodology upon which Mr. Kennedy relied. (*Id*. at 11–12; *see also* Dkt. No. 706 at 5.) As with Apple's objections regarding Dr. Kennedy's infrastructure approach, Optis contends that Apple's objection to the survey approach is merely a "late *Daubert* attack against methodology that Apple has already raised and has already been rejected, or has been waived by not being brought at the proper time." (Dkt. No. 707 at 11.)

Apple again argues that a "challenge to sufficiency of evidence" to support a verdict is "separate from a *Daubert* challenge." (Dkt. No. 711 at 2.) Apple also contends that Optis did not base its damages calculation on this approach and therefore the approach cannot support any verdict. (*Id*. at 4.) Further, Apple argues that Optis's conclusion that Apple priced fast phones higher than slower phones was erroneous because "the record shows that Apple regularly drops price of older models when introducing a new one." (*Id*.) Relatedly, Apple contends that both LTE and non-LTE phones had the same price when launched—it was only after launch of a new model that Apple would decrease the price of an older model. (Dkt. No. 710 at 3.) Finally, Apple repeats the argument that Dr. Reed-Arthurs's survey was "never used in the real-world" and was based on "hypothetical products," but contends that its own expert, Dr. Perryman, used a "widely accepted" methodology that should have been credited. (Dkt. No. 711 at 5; *see also* Dkt. No. 710 at 2–3.)

Optis first responds that Dr. Reed-Arthurs explained to the jury that the price comparisons of the LTE and non-LTE phone models must be done at the same point in time, and cannot be

based on their launch prices at different points in time. (Dkt. No. 717 at 3.) Optis argues more generally that Apple cross-examined Dr. Reed-Arthurs on the survey upon which Mr. Kennedy relied and that the jury was entitled to weigh the testimony of Dr. Reed-Arthurs, Mr. Kennedy, and all supporting documentation and competing testimony from Dr. Perryman, in evaluating the survey approach. (Dkt. No. 716 at 4–5.)

As this Court has previously held, it is improper to use a JMOL motion—or a motion for new trial—as a renewed *Daubert* challenge. *Rembrandt Wireless Techs., LP v. Samsung Elecs. Co., Ltd.*, 2016 WL 362540, at *3–4 (E.D. Tex. Jan. 29, 2016). As with Mr. Kennedy's infrastructure approach *supra*, the Court finds that Apple's attack on Mr. Kennedy's survey approach was already rejected by the Court at the *Daubert* stage. (*See* Dkt. No. 438 at 27:23–28:11.) Accordingly, Apple's arguments related to the reliability of Mr. Kennedy's methodology are again rejected on the same grounds. *Versata*, 717 F.3d at 1264.

***iv. JMOL and New Trial: Mr. Kennedy's Reliance on Qualcomm Agreements***

Apple contends that Mr. Kennedy's reliance on Apple's agreements with Qualcomm was prejudicial and irrelevant because those agreements totaled [redacted] and [redacted] in this case. (Dkt. No. 700 at 8.) Apple also argues that the agreements between Apple and Qualcomm were excluded in another case for the same reason. (Dkt. No. 699 at 7.) Apple argues that the agreements are not relevant because (1) [redacted] (compared to the five at issue here), (2) the licenses were [redacted], (3) the agreements also [redacted], and (4) the licenses [redacted]. (Dkt. No. 700 at 9–12; *see also* Dkt. No. 699 at 8.) Apple states that Mr. Kennedy merely referred to these agreements as "important" and "relevant," which did not demonstrate that they were comparable.

(Dkt. No. 699 at 7.) Apple also alleges that comparable licenses *did* exist, but that Mr. Kennedy did not opine on them. (Dkt. No. 700 at 13.)

Optis argues that this Court has previously held that the Qualcomm agreements are properly before the jury and already rejected this argument when it denied Apple's *Daubert* motion and a motion *in limine* ("MIL") on the same issue. (Dkt. No. 706 at 6; *see also* Dkt. No. 707 at 13 (citing Dkt. No. 455 at 7; Dkt. No. 668 at 10).) Optis clarifies that [redacted] (Dkt. No. 707 at 14.) According to Optis, Mr. Kennedy relied on [redacted] (2) to rebut Apple's position that [redacted] and (3) to "call[] into doubt the royalty stack theory upon which Apple" based its damages case. (Dkt. No. 707 at 14; *see also* Dkt. No. 706 at 6–7.) Specifically, Optis contends that Mr. Kennedy [redacted] (Dkt. No. 707 at 15.) Optis argues that Mr. Kennedy used [redacted], [redacted] to the rate he calculated in this case. (*Id.* at 15–16.) Moreover, Optis contends that Mr. Kennedy used the same methodology that Apple's own expert used to determine a per-patent rate in another case. (*Id.* at 16.) Optis emphasizes that Mr. Kennedy did not use the [redacted] (*Id.* at 17.) Instead, he used the [redacted] as a "check" on his own calculation based on the "relevance and comparability" [redacted] which the jury was free to evaluate. (*Id.* at 18.) Optis contends that Mr. Kennedy's use of the Qualcomm agreements was justified by their [redacted]

[redacted] (Dkt. No. 706 at 7.) Finally, Optis notes that Apple cross-examined Mr. Kennedy on the agreements and the jury was free to weigh that testimony. (*Id.* at 7–8.) Optis clarifies that this cross-examination did not contain any questions about the relevance of the Qualcomm agreements. (Dkt. No. 707 at 13.)

In response, Apple reiterates that the Qualcomm agreements were "wholly irrelevant and noncomparable in every aspect" for which Optis used them. (Dkt. No. 711 at 5.) Apple also argues that Mr. Kennedy "never testified [redacted] and contends that it was not Apple's duty to cross examine Mr. Kennedy on the relevance of the agreements because it is "Plaintiffs' burden to factually establish damages" and the "comparability of licenses." (*Id.*) Apple also contends that although both parties introduced license agreements, it was only *Optis* that introduced [redacted] (Dkt. No. 710 at 3.) According to Apple, this was prejudicial because it was the "focus" of Optis's damages case. (*Id.*) Apple also argues that if Optis only [redacted] (*Id.*) Apple maintains that Optis's introduction of the Qualcomm agreements "skew[ed] the damages horizon [redacted] even despite the fact that Apple's objection did not mention the entire market value rule. (*Id.*)

Optis contends that Apple itself introduced a "large number of [redacted]" that its own expert admitted were not comparable or [redacted] and argues that Apple "cannot credibly argue that its own behavior was justified" and move for a new trial based on the same behavior by Optis. (Dkt. No. 716 at 5; Dkt. No. 717 at 3.) Optis argues that, in contrast, the evidence shows that the [redacted] (Dkt. No. 716 at 5.) Moreover, Optis cites Federal Circuit precedent holding that "licenses

relied on by a patentee in proving damages need only be 'sufficiently comparable.'" (*Id.* (citing *Virnetx, Inc. v. Cisco Sys., Inc.*, 767 F.3d 1308, 1330 (Fed. Cir. 2014)).) Optis repeats that Mr. Kennedy [redacted] (Dkt. No. 716 at 6.) Indeed, Optis argues that Mr. Kennedy used the [redacted] is the proper way to license SEPs." (Dkt. No. 717 at 3.)

The Court has already held that the Qualcomm agreements were properly before the jury. (*See*, *e.g.*, Dkt. No. 455 at 7.) Mr. Kennedy explained to the jury his reliance on the Qualcomm agreements and [redacted] (*See*, *e.g.*, Dkt. No. 692 at 175:21–176:3, 177:21–178:21, 179:7–180:17, 180:22–181:15, 234:4–235:11.) Apple cross-examined Mr. Kennedy on the agreements, but Optis argues that this cross-examination did not contain any questions about the relevance of the Qualcomm agreements. (Dkt. No. 707 at 7–8, 13.) Moreover, Apple's damages expert, Dr. Perryman, provided his own opinions on the Qualcomm agreements and Mr. Kennedy's testimony on the same. (*See*, *e.g.*, Dkt. No. 693 at 168:2–20.) The jury was entitled to weigh all the evidence presented at trial and decide which evidence it found to be most credible. *See Finjan, Inc. v. Secure Computing Corp.*, 626 F.3d 1197, 1212 (Fed. Cir. 2010). After such evaluation, the jury found for Optis. The Court does not find that no reasonable jury could have relied upon Mr. Kennedy's analysis of [redacted]. Where a jury is presented with two conflicting positions at trial and there is reasonable evidence and argument to support both positions, the fact that the jury ultimately sided with one party over the other does not support entry of JMOL and does not support granting a new trial. Making such decisions is, in fact, the essence of the jury trial system.

*v. JMOL and New Trial: Mr. Kennedy's Bargaining Share Analysis*

Mr. Kennedy opined that Optis would have captured [redacted] of Apple's purported profits from infringement, which Apple argues was not tied to the facts of the case and should have been excluded. (Dkt. No. 699 at 9.) Apple contends that Mr. Kennedy's "bargaining share analysis" was not tied to the facts of this case because it was based on [redacted] to which Apple was not a party. (Dkt. No. 700 at 14–15.) Apple also alleges that Mr. Kennedy "admitted" that none of Optis's licenses were comparable to the hypothetical negotiation, but still used those licenses to determine an agreed profit split. (Dkt. No. 699 at 9.) Apple contends that Mr. Kennedy's analysis was not "already apportion[ed]" to the value of the asserted patents because the baseline reflected "thousands of LTE patents." (Dkt. No. 710 at 3.) Apple also argues that Optis did not offer evidence that the [redacted] would "inform a profit split with Apple" or "why [redacted] would be similarly situated to Apple." (Dkt. No. 710 at 3; Dkt. No. 711 at 7.)

Optis contends that Apple's argument "misrepresent[s] the trial record to the Court." (Dkt. No. 707 at 19.) Optis also argues that this is simply "another rehash" of Apple's *Daubert* arguments, which the Court denied. (Dkt. No. 706 at 8.) Specifically, Optis contends that "Mr. Kennedy's damages analysis already apportions down to the technical value" of the asserted patents and, "to be conservative," and without any obligation to do so, Mr. Kennedy applied a further discount based on a review of PanOptis' negotiation history with, for example, [redacted]. (*Id; see also* Dkt. No. 707 at 18–19.) Optis also contends that Mr. Kennedy fully explained how he reached the [redacted] (Dkt. No. 707 at 19.) According to Optis, Mr.

Kennedy considered this as evidence of PanOptis's negotiation behavior, and not as an indication of the reasonable royalty. (*Id.*) Optis also contends that Mr. Kennedy explained to the jury why the [redacted] bargaining splits, as demonstrated by exhibits on the record, would "inform Plaintiffs' behavior in a hypothetical negotiation with Apple." (Dkt. No. 716 at 6; Dkt. No. 717 at 3.)

The Court finds that Mr. Kennedy's bargaining share conclusion is supported by substantial evidence and does not warrant a new trial. Mr. Kennedy properly explained the basis for his bargaining share analysis to the jury, including his opinion that reliance on the [redacted] "reflects PanOptis'[s] past negotiation behavior and the likely behavior in a hypothetical negotiation." (Dkt. No. 707 at 19 (citing Dkt. No. 692 at 172:22–173:19, 174:22–175:1).) Apple's post-verdict critique of Mr. Kennedy's bargaining share analysis is once again an untimely *Daubert* attack that has already been rejected by this Court. (*See* Dkt. No. 438 at 27:23–28:11.)

***vi. JMOL and New Trial: LTE Standard***

Apple argues that Optis improperly attempted to "capture the value of the whole LTE standard, notwithstanding that the value of [LTE] standardization comes from thousands of technology contributions." (Dkt. No. 700 at 16; *see also* Dkt. No. 699 at 3.) According to Apple, its expert Dr. Perryman testified that thousands of other patents have been declared essential to LTE, but that Optis did not consider those in its apportionment. (Dkt. No. 700 at 16; *see also* Dkt. No. 699 at 3.) Based on this, Apple contends that Optis did not apportion between the value of the asserted patents and the value of the standard, nor did Optis apportion the supposed contributions of the asserted patents to LTE compared to the contributions of others to LTE. (Dkt. No. 700 at

16.) Apple argues that Optis repeatedly referred to speed and price differences of Apple's LTE products over other LTE devices without attributing those differences to the asserted patents. (*Id.*)

Optis contends that this is another untimely *Daubert* attack which Apple has waived. (Dkt. No. 706 at 3.) Optis also argues that Mr. Kennedy's damages analysis was apportioned to the technical benefit of the asserted patents because it relied on Dr. Mahon's and Dr. Madisetti's analyses, which were based on "the incremental increase in network performance achieved by the patented technology when all other aspects of the network are kept the same and the next best non-infringing alternative is used instead of the patented technology," without taking into account "any value added by the standardization of that technology." (Dkt. No. 707 at 20; *see also* Dkt. No. 706 at 3.) Optis also contends that Mr. Kennedy's damages opinions "were only based on the incremental benefits of the patents-in-suit (*i.e.*, increases in upload and download speed), and any references to the value of LTE were made with respect to LTE speed." (Dkt. No. 707 at 4; *see also id*. at 20.) Optis maintains that Mr. Kennedy never considered the value of standardization to the patents in any stage of the analysis. (*Id*. at 20.) Further, Optis contends that when Dr. Mahon referred to the "download speed" of the iPhone in terms of "more LTE," he was referring to the fact that Apple uses and demands higher speed data. (*Id*. at 21–22.) Optis claims that Apple did not present any contrary evidence. (*Id*. at 22.) Optis finally argues that Apple allowed this testimony to continue at trial "without objection" and thus waived any argument for a new trial on this basis. (*Id*. at 4.)

In response, Apple criticizes Optis for not considering the value of standardization to the patents, arguing that this did not excuse Optis from apportioning because the baseline from which Optis "measured performance encompasses contributes from thousands of other LTE patents that Plaintiffs' experts ignored." (Dkt. No. 711 at 7; *see also* Dkt. No. 710 at 2.) Apple also contends

that Optis offered "no evidence that Apple's LTE devices' speed gains over other LTE devices (all of which would use the same LTE SEPs) can be attributed to" the asserted patents. (Dkt. No. 711 at 7–8.) Apple argues that it preserved this argument by seeking to exclude such evidence in its MILs and obtaining a running objection on the topic. (Dkt. No. 710 at 2.)

Optis states that "Mr. Kennedy's analysis ensured that the damages in this case did not award to Plaintiffs any of the value associated with standardization" and thus his analysis was apportioned to the "*ex ante* technical benefit" of the asserted patents based on expert analyses of the "incremental increase in network performance achieved by the patented technology." (Dkt. No. 716 at 6–7.) Optis argues that because Mr. Kennedy never included the value of standardization in his calculation to begin with, there was no need to later apportion it out. (Dkt. No. 717 at 2.) Optis also contends that Apple was wrong to assert that Optis offered no evidence that "Apple's LTE devices' speed gains are attributed to" the asserted patents and points to testimony explaining such evidence. (Dkt. No. 716 at 7 (citing Dkt. No. 691 at 249:6–13, 254:2–12; Dkt. No. 692 at 26:25–27:7, 35:3–8, 43:10–15).)

*Ericsson* mandates that "[w]hen the accused infringing products have both patented and unpatented features, . . . [t]he essential requirement is that the ultimate reasonable royalty award must be based on the incremental value that the patented invention adds to the end product." *Ericsson, Inc. v. D-Link Sys., Inc.*, 773 F.3d 1201, 1226 (Fed. Cir. 2014). Here, Optis contends that Dr. Madisetti and Dr. Mahon "examined the incremental value that the patented invention adds to Apple's products, *e.g.*, the improvement in speed to Apple's products, as opposed to other (non-comparable) products" and, based on such incremental value, Mr. Kennedy computed damages that did not include "any value added by the standardization of that technology." (Dkt. No. 706 at 3 (quotations omitted).) As a result, Mr. Kennedy did as *Ericsson* instructs: he calculated a "royalty

for SEPs" that "reflect the approximate value of that technological contribution, not the value of its widespread adoption due to standardization." *Ericsson*, 773 F.3d at 1233.

The Court finds that the jury had sufficient evidence and explanation of Mr. Kennedy's apportionment analysis and Apple's arguments to the contrary do not warrant a new trial.

***vii. JMOL and New Trial: References to Apple's Share of Total Cellular Profits***

Apple alleges that Optis "improperly referred repeatedly—over Apple's objections—" to Apple's profits across the cellular industry, which amounted to approximately [redacted] of the entire industry. (Dkt. No. 699 at 2.) Apple argues that such evidence suggested to the jury that Apple should disgorge its profits, which was not an available remedy. (*Id.*; *see also* Dkt. No. 700 at 17–18.) Apple also argues that Optis failed to establish any nexus between Apple's share of profits in the cellular industry and the LTE capabilities of its products and thus did not show that the patented features drove any industry-wide profitability. (Dkt. No. 700 at 18–19; *see also* Dkt. No. 699 at 3.) Apple argues that focusing on Apple's share of the cellular market was prejudicial because it improperly suggested that Apple should pay more because its devices are more profitable than the competition. (Dkt. No. 700 at 19.)

Optis contends that Apple's argument regarding Apple's share of cellular profits has been waived because Apple did not object when testimony about Apple's share of profits was presented to the jury. (Dkt. No. 707 at 4.) Optis also argues that Apple requested the retrial to calculate a FRAND rate, the non-discrimination prong of which requires that "similarly situated" companies get "similar licensing terms." (Dkt. No. 706 at 2.) Thus, Optis contends that evidence showing Apple's "huge presence in the market" and "overall size" puts them in a "different posture than other parties" for purposes of the FRAND analysis. (*Id.*) Optis also points out that Apple repeatedly introduced Samsung's position and size within the industry when cross-examining Optis's

witnesses to "attempt to make a false comparison between Apple and Samsung" and argue that Apple is "similarly situated" to Samsung for purposes of determining a FRAND royalty. (Dkt. No. 707 at 23.) Optis contends that "Apple's place in the market and, specifically, how Apple is situated with respect to Samsung, is directly relevant to the FRAND royalty here because Apple has repeatedly argued that it should be treated identically to Samsung." (*Id*. at 24.) Optis argues that to counter the unit sales comparisons between Apple and Samsung, Optis properly raised the profitability comparison, to which Apple did not object during trial. (Dkt. No. 706 at 2–3.) Optis essentially points out that Apple opened this door by its injection of Samsung's size and position into this trial. Finally, in response to Apple's argument that evidence regarding its share of the market is discriminatory because it implies that Apple should pay more due to the profitability of its products, Optis contends that the Fifth Circuit has rejected this argument as "transform[ing] the non-discrimination element of FRAND into a most-favored licensee approach." (Dkt. No. 707 at 24 (citing *HTC Corp. v. Telefonaktiebolaget LM Ericsson*, 12 F.4th 476, 486 (5th Cir. 2021).)

Apple argues that the *HTC* case is inapposite because in a patent damages case involving FRAND, the royalty "must be based on the incremental value of the invention" and not based on the relative situations of the parties. (Dkt. No. 711 at 8.) Apple also argues that even if some evidence "as to whether Apple is similarly situated to other firms" might be relevant, Optis cannot use that as a "backdoor to promote (and rely on) irrelevant, discriminatory, and unduly prejudicial revenue and/or profit numbers" that have been previously found inadmissible. (*Id*.) Apple further contends that it preserved its argument by seeking to exclude references to its profits through MILs and a running objection, thus arguing that it did not need to object to such testimony during trial. (Dkt. No. 710 at 1.) Nevertheless, Apple argues that it *did* object to certain of Mr. Kennedy's testimony on the topic when accompanied by certain slides. (*Id*.)

Optis argues that Apple does not dispute that "evidence as to whether Apple is similarly situated as to others in the industry" is relevant to a FRAND analysis. (Dkt. No. 716 at 7.) Optis contends this is especially true in light of Apple's repeated comparisons to Samsung during the trial. Optis criticizes Apple for asserting that "the number of LTE products it sells as compared to Samsung is relevant to a FRAND license, but its profitability in selling those products as compared to Samsung is somehow irrelevant to a FRAND license." (*Id*. at 8.) Optis argues that Apple's comparisons to Samsung in terms of unit sales opened the door to Optis's discussion of Apple's relative profits. (*Id*.) Thus, Optis maintains that "Apple cannot credibly argue it was prejudiced by evidence it chose to affirmatively introduce on cross-examination with Plaintiffs' first witness." (Dkt. No. 717 at 1.) Optis also argues that Apple's running objection tied to Apple's MIL 8 did not relate to Apple's comparable profitability in the industry, but only to Apple's overall pricing of, and profits from, cellular technology as a whole. (*Id*.)

The Court agrees with Optis that "Apple cannot credibly argue it was prejudiced by evidence [of relative unit sales] it chose to affirmatively introduce on cross-examination with Plaintiffs' first witness." (Dkt. No. 717 at 1.) The non-discrimination prong of FRAND, as Apple's own expert testified, requires analysis of "similarly situated, similar companies." (Dkt. No. 693 at 135:9–13.) Apple introduced relative unit sales between itself and Samsung throughout trial, both on direct and cross-examination, in an attempt to argue that Apple is "similarly situated" to Samsung. (*See, e.g.*, Dkt. No. 691 at 188:18–24, 191:2–6; Dkt. No. 692 at 185:10–14; Dkt. No. 694 at 70:2–9.) Optis was permitted to rebut this testimony with evidence of relative profits based on those relative unit sales. Moreover, as to Apple's concern that such evidence "suggested" to the jury that Apple should disgorge its profits (Dkt. No. 699 at 2; Dkt. No. 700 at 17–18), the jury was properly instructed on the applicable law and a "jury is presumed to follow the [C]ourt's

instructions." *Datatreasury Corp. v. Wells Fargo & Co*., 2010 U.S. Dist. LEXIS 143587, at *15 (E.D. Tex. Sep. 27, 2010). The Court thus finds that substantial evidence exists supporting the jury's verdict Apple's and arguments regarding its share of total profits in the cellular industry do not compel setting aside the jury's verdict and granting a new trial.

***viii. JMOL: Evidence of Actual Infringing Use of Method Claims***

Apple argues that as to method claims 14 and 27 of the '284 patent, claim 10 of the '557 patent, and claim 6 of the '774 patent, Optis failed to prove the extent of actual infringing use in the United States. (Dkt. No. 700 at 20.)

In response, Optis first argues that Apple waived this argument by not seeking a jury instruction on infringing use of method claims. (Dkt. No. 707 at 25; *see also* Dkt. No. 716 at 8.) Optis also contends that the Court has already determined that Optis offered substantial evidence of infringing use of each method claim during the first trial and, since damages can be based upon sales of devices, there was no need for Optis to present its infringing use evidence again at the damages retrial. (Dkt. No. 707 at 25.)

Apple contends that the Court's prior rulings were "silent on the *extent* of infringing use." (Dkt. No. 711 at 9) (emphasis in original). Apple also argued that it did not waive this argument because it related to sufficiency of the evidence presented and was raised in Apple's Rule 50(a) motion. (*Id*.)

Apple did not seek a jury instruction regarding infringing use of method claims. (Dkt. No. 707 at 25 (citing Dkt. No. 677).) Moreover, the Court has already found that Optis offered substantial evidence of infringing use of each method claim at the first trial. (*See* Dkt. No. 667 at 8–9, 15, 20–21.) As the second trial was one for damages only, Optis was not required to rehash its infringement arguments before the jury. Despite this, Optis's experts opined on infringement

of each asserted claim. (*See, e.g.*, Dkt. No. 691 at 236:10–14, 240:20–241:19, 251:16–19; Dkt. No. 692 at 35:11–13, 41:16–42:6, 43:12–15.) Taken together, along with the verdict form and jury instructions, which informed the jury that the "patents-in-suit are valid and infringed," (Dkt. No. 706 at 1 (citing Dkt. No. 677 at 11, 22)), the Court finds that the jury was presented with substantial evidence of infringement sufficient to support its damages calculation.

***ix. JMOL: Performance Benefits Analysis***

Apple claims the opinions of Dr. Madisetti and Dr. Mahon regarding the performance benefits that the asserted patents provide (over the closest non-infringing alternatives) are unreliable, and it contends that on this basis, Optis's entire damages case collapses. (Dkt. No. 700 at 20–21.) Specifically, Apple contends that the testing evidence presented by Dr. Madisetti and Dr. Mahon was "based on unreliable data and analysis from Mr. Royer and TechPats, who destroyed key calibration data, . . . performed testing in one location not representative of the United States as a whole, . . . and provided data shown to be uncredible on cross examination." (*Id*. at 21.) Apple also contends that simulations performed by Dr. Virdis, on which Dr. Madisetti relied, did not reflect real-world conditions. (*Id*.) As a result, Apple contends that the jury could not credit Optis's testing and simulation evidence and therefore that any damages opinions or benefit analyses relying on those calculations should fail. (*Id*.; *see also generally id*. at 21–28.) Apple also argues that the testimony cited on this point by Optis was "conclusory" and insufficient to support the verdict in this case. (Dkt. No. 711 at 9–10.)

Optis argues that Apple chose not to call any technical experts or fact witnesses at trial to contradict any of Optis's conclusions on this topic, waiving any objections to such testimony. (Dkt. No. 707 at 25.) Further, Optis contends that "if Apple believed that it was necessary to explore data underlying those opinions, Apple had the obligation to cross-examine each expert on that

evidence." (*Id*. at 26.) Apple did not do so. (*Id*.) Optis also argues that its experts explained each of the simulations they ran, as well as similar simulations that they used as checks on their results. (*Id*. at 26–30.)

The Court agrees with Optis that, if Apple "believed that it was necessary to explore data underlying" the opinions of Optis's experts, Apple should have cross-examined Optis's experts, or called its own technical or fact witnesses to rebut the testimony of Optis's witnesses. Also, Optis is correct that there was no order from this Court requiring either Dr. Mahon or Dr. Madisetti to "testify to all the underlying facts or data" upon which they based their opinions pursuant to Federal Rule of Evidence 705. (Dkt. No. 707 at 26.) This squarely placed the burden upon Apple to cross-examine Optis's experts on their performance and technical benefits analyses, but Apple failed to meet that burden. Thus, the testimony of Optis's experts on the topic was unrebutted, and the jury had sufficient evidence on the topic to consider. To the extent Apple's arguments are another of its renewed *Daubert* attacks on the methodologies of Optis's experts, Apple's arguments are also rejected as improper. *Rembrandt Wireless*, 2016 WL 362540, at *3–4.

***x. JMOL: $300 Million Award***

Apple argues that the $300 million damages number did not appear in the record and is not "based in reality," arguing instead that the record included [redacted]. (Dkt. No. 700 at 28.) Apple also points out that while the jury did not accept Optis's theory as to the original $506 million damages ask, their ultimate $300 million calculation was unsupported by the record. (*Id*. at 28–29.)

Optis contend that Apple's argument here has been waived because Apple did not raise it in its 50(a) motion. (Dkt. No. 707 at 5 (citing *Arsement v. Spinnaker Expl. Co*., 400 F.3d 238, 247 (5th Cir. 2005) ("If a party fails to raise an issue in its Rule 50(a)(1) motions at trial, it may not do

so in its post-trial Rule 50(b) motion.”)).) Optis also argues that the jury did not have to award *either* party’s damages figure but could “substitute an intermediate figure as a matter of its judgment from all of the evidence.” (*Id.* at 30 (quoting *SmithKline Diagnostics, Inc. v. Helena Labs. Corp.*, 926 F.2d 1161, 1167–68 (Fed. Cir. 1991)).) In response to Apple’s argument that the [redacted] should have been used to calculate the jury’s award, Optis argues that [redacted], rather than the “fully paid-up lump sum that the jury awarded here,” and ignored the fact that [redacted]. (Dkt. No. 707 at 30.)

Apple counters that Optis “fail[s] to identify a single flaw” in its expert Dr. Perryman’s figures, and as such *his* was the only figure supported by the evidence. (Dkt. No. 711 at 10.) Apple also argues that the jury verdict issued the day after Apple presented its Rule 50(a) motion and thus could not have been presented in such motion. (*Id.* at n.10.)

Optis argues that at the damages retrial, Apple elected not to call any experts to challenge Dr. Mahon’s and Dr. Madisetti’s conclusions about technical value and it has waived any argument against the weight of their testimony. (Dkt. No. 716 at 9.) Optis contends that even if Apple could not have raised the argument in their 50(a) motion, it should have been raised in its motion for a new trial. (*Id.* at 10.)

Apple’s main argument against the ultimate damages award is that the “number cannot be found anywhere in the trial record,” *i.e.*, in the testimony of Optis’s experts, or in comparable licenses. (Dkt. No. 700 at 28.) However, in many cases, the factual determination of a reasonable royalty is not supported by the specific figures advanced by either party’s damages expert and the jury is free to substitute a figure “as a matter of its judgment from all of the evidence.” *Apple Inc. v. Motorola, Inc.*, 757 F.3d 1286, 1328 (Fed. Cir. 2014) (citing *SmithKline*, 926 F.2d at 1167–68.)

Here, Optis asked the jury to award damages of $506 million in the form of a running royalty. (*See, e.g.*, Dkt. No. 694 at 90:24–91:5.) Apple, on the other hand, alleges that [redacted] (Dkt. No. 700 at 28 (citing Dkt. No. 692 at 203:13–206:12.) The jury ultimately awarded $300 million in damages—a number between those separately advanced by the parties. As discussed above, the Court finds that substantial evidence supports the jury's verdict. Having considered all the record evidence, the Court concludes that the jury reached a reasoned and supportable decision and declines to disturb the jury's judgment.

***xi. New Trial:*** [redacted]

Apple stated that its MIL 4, which the Court rejected, sought to preclude reference to [redacted]. (Dkt. No. 699 at 10.) Apple argues that such evidence and testimony should have been excluded because (1) [redacted] were "irrelevant to the jury's sole task of determining a FRAND royalty based on a 2012 hypothetical negotiation," (2) [redacted] was irrelevant, and (3) the use of such information [redacted]. (*Id.* at 11.) Apple argues that [redacted] (*Id.*)

Optis responds that [redacted] (Dkt. No. 706 at 8.) Optis contends that Apple [redacted]. (*Id.* at

9.) Optis maintains that Apple "cannot seek a new trial based on evidence it sought to introduce." (*Id.*) Additionally, Optis argues that [redacted], which is relevant to the FRAND issue. (*Id.*) Optis also notes that the Court's instruction to the jury to assume that both parties were willing to enter into an agreement, as well as the Court's instruction that their damages award should not "punish" the alleged infringer, should be credited as "obviating Apple's concern for prejudice." (*Id.* at 9–10.)

Before trial, Apple stated that [redacted] (Dkt. No. 710 at 3) (quotations omitted). Apple contends that it repeatedly raised this position at the pretrial conference and before trial, where the Court granted a running objection. (*Id.* at 4.) Apple argues that it was *Optis* who opened the door to this testimony over Apple's objection. (*Id.*) In contrast, Optis maintains that Apple stated "unequivocally" that [redacted]. (Dkt. No. 717 at 4.)

Apple is correct that the Court denied Apple's MIL 4 which sought to [redacted]. (Dkt. No. 633 at 4–5.) In doing so, the Court found that in relation to the FRAND issue, [redacted] (Dkt. No. 651 at 75:21–76:26.) Based on the denial of its MIL 4, Apple stated that [redacted]

[redacted] (Dkt. No. 706 at 8–9 (citing Dkt. No. 691 at 217:2–12; Dkt. No. 692 at 302:15–304:25).) "[O]ne waives his right to object to the admission of evidence if he later introduces evidence of the same or similar import himself." *Manderson v. Chet Morrison Contractors, Inc*., 666 F.3d 373, 380–81 (5th Cir. 2012).

This Court allowed [redacted]. (*See, e.g.*, Dkt. No. 706 at 8–9.) Apple's concern that [redacted] (Dkt. No. 699 at 11) was obviated by the Court's instruction to the jury to assume that both parties were willing to enter into an agreement, as well as the Court's instruction that their damages award should not "punish" the alleged infringer. The "jury is presumed to [have] follow[ed] the [C]ourt's instructions." *Datatreasury*, 2010 U.S. Dist. LEXIS 143587, at *15. The Court finds that any reference to the parties' negotiation history was not so prejudicial as to warrant a new trial.

***xii. New Trial: Exclusion of Prior Art Evidence***

Apple contends that it sought to show the technical value of the claimed features by presenting evidence that the claimed features were already known, but argued that the Court's grant of Optis's MIL 12 excluded such evidence as "inviting a retrial as to invalidity." (Dkt. No. 699 at 11.) Apple argues that this ruling prohibited Apple from showing how small the

improvement was of the asserted patents, which it contends is directly relevant to *Georgia-Pacific* factor 9 regarding utility and advantages over old modes. (*Id*. at 12.)

Optis argues that whether individual elements of a claim are known in the art is irrelevant to the damages analysis. (Dkt No. 706 at 10.) Optis also notes that Apple was not excluded from introducing prior art or evidence relevant to *Georgia-Pacific* factor 9, but only theories of non-infringement or invalidity. (*Id*.) Moreover, Optis maintains that Apple chose not to bring its technical experts to trial, nor did it seek to cross-examine Dr. Madisetti on prior art. (*Id*. at 11.) Optis argues that it was Apple's decision, not the Court's, not to elicit testimony on the "purported state of the art," thus waiving any objection by Apple. (*Id*.)

Apple specifically contends that the Court improperly excluded its allegedly prior art exhibit, DX-171, in a chambers conference based on its previous grant of Optis's MIL 12. (Dkt. No. 710 at 4.) In contrast, Optis argues that the "record is clear" that the Court left the door open for Apple introduce the exhibit it contends the Court "excluded," and Optis also notes that the Court never granted Optis's written motion to exclude the same. (Dkt. No. 717 at 4.) Thus, Optis contends that it was Apple's choice not to introduce DX-171. (*Id*.)

The Court did not exclude exhibit DX-171 from the case. Rather, DX-171 was admitted in the original trial and thus pre-admitted in the damages retrial. (*See generally* Dkt. 651 at 131:14–138:5 ("DX-171 is in this trial.").) When it took up Optis's MIL 3, the Court recognized that "there are exhibits that were pre-admitted and used in the prior trial that were used for purposes that don't relate to damages" and "would relate solely to issues that have already been tried and decided and would not relate to the damages issue." (*Id*. at 136:1–22.) Optis's MIL 12, in contrast, sought to exclude "technical benefit analyses that assume non-infringement or invalidity." (Dkt. No. 634 at 10–11.) At the pretrial conference, Optis argued that Apple "convert[ed] its non-

infringement and invalidity defenses," which were "rejected" in the first trial, "into damages defenses" at retrial. (Dkt. No. 651 at 37:1–38:13.) The Court granted this MIL to prevent "a retrial as to invalidity." (*Id*. at 40:11–14.) In doing so, the Court noted that it was "not an absolute prohibition" on seeking leave to present "targeted" technical testimony or evidence on the topic. (*Id*.)

The Court's grant of Optis's MIL 12 did not exclude evidence related to prior art or *Georgia-Pacific* factor 9 which would establish the technical value of the claimed features. In fact, the Court expressly accounted for the possibility that certain testimony about prior art would be relevant and useful, and stated that the Court would grant leave if were warranted. (*Id*.) However, Apple chose not to bring technical experts to the retrial, nor did it seek leave from the Court to present any testimony regarding prior art. Apple cannot now seek a new trial based on evidence that was never excluded and regarding which Apple never sought leave from the Court to present to the jury. Apple's argument does not compel granting a new trial.

***xiii. New Trial: Exclusion of Component Licensing Evidence***

Apple contends it was improperly barred from offering evidence that LTE SEPs are licensed at the baseband processor level, including evidence that [redacted]. (Dkt. No. 699 at 12.) Apple contends that at the MIL stage, the Court "wrongly assumed" this evidence was related to exhaustion, but argues that it was separately relevant to show [redacted]. (*Id*.; *see also* Dkt. No. 710 at 4.) This impacted a "key" disputed issue of whether the baseband processor was the smallest saleable patent-practicing unit. (Dkt. No. 699 at 12–13.)

Optis argues that exhaustion-related evidence was properly excluded, but that no component licensing evidence was excluded. (Dkt. No. 706 at 11.) Instead, Optis contends that the Court excluded [redacted] (*Id*. at 11–12.) As to the component licensing evidence, Optis argues that the "Court never ruled on this issue" and as such, no evidence was excluded. (*Id*. at 12.) Optis also contends that Apple's expert, Dr. Perryman, only discussed component licenses with respect to exhaustion in his report, and thus could not have even introduced such licenses at trial with respect to component licensing. (Dkt. No. 717 at 4.)

At the pretrial stage, the Court granted Optis's MIL 8, which precluded Apple from referencing [redacted]. (*See generally* Dkt. No. 634 at 7; *see also* Dkt. No. 651 at 35:15–18 ("In my view, exhaustion is a defense to liability and not a defense or a limitation on damages. This wasn't tried at the first case. I see no need to get into it in this damages retrial.").) The Court's ruling on Optis's MIL 8 did not exclude "evidence that LTE SEPs are licensed at the baseband processor level." (Dkt. No. 699 at 12.) Apple argues that [redacted] (*Id*.) The Court never ruled on evidence of component licensing separate from exhaustion issues, and thus Apple was not precluded from presenting such evidence at trial. Apple's argument does not support granting a new trial.

***xiv. New Trial: Prior Infringement Jury Instructions***

Apple contends that the Court's instruction that Apple had previously been "found" to infringe, without curative instruction that Optis's references to Apple's infringement were

improper, was prejudicial. (Dkt. No. 699 at 13.) Instead, Apple argued that the jury only needed to be instructed on a hypothetical negotiation. (*Id.*)

Optis responds that the Court's instruction was "legally and factually correct" and that the Court previously denied Apple's request that the jury be instructed to merely "assume" infringement and validity. (Dkt. No. 706 at 12–13.)

However, Apple contends that the standard jury instruction to "assume" validity and infringement was sufficient and should have been used. (Dkt. No. 710 at 4.) Apple argues that Optis did not explain why the standard instruction was inadequate. (*Id.*)

Optis contends that instructing on the previous finding of infringement was "mandated" by Federal Circuit precedent. (Dkt. No. 717 at 5 (citing *AstraZeneca AB v. Apotex Corp*., 782 F.3d 1324, 1330–33 (Fed. Cir. 2013)).)

Damages may only be awarded upon a finding of infringement. Thus, in a retrial on damages issues only, an instruction that Apple was previously found to infringe the asserted patents is proper. Moreover, the Court previously denied Apple's proposed instruction at the pretrial stage—that the jury merely "assume" infringement. (*See generally* Dkt. No. 633 at 1; *see also* Dkt. 651 at 29:11–13.) Since Apple did not secure a new trial except on damages, it improperly argues the prior trial should be simply ignored or treated as if it did not occur. The jury instruction was legally and factually correct. Accordingly, Apple's argument does not compel granting a new trial.

### *xv. New Trial: Comparable License Jury Instructions*

Apple argues that it presented evidence on comparable licenses, but that Optis presented only the noncomparable Qualcomm agreements. (Dkt. No. 699 at 13–14.) Apple requested that the jury be instructed regarding the "appropriate" use of licenses to determine damages but that the

Court "refused." (*Id*. at 14.) Apple fears the jury may have given "undue weight" to the noncomparable license. (*Id*.)

Optis argues that the jury was instructed on the evaluation of comparable licenses, but Apple's proposed instruction had no supporting authority. (Dkt. No. 706 at 13.) Optis also contends that it was *Apple* who introduced admittedly noncomparable licenses over Optis's objection, so any purported lack of instruction on evaluation of licenses harmed Optis, not Apple. (*Id*. at 14.)

Apple argues that it was error for the Court not to instruct that a comparable license needs to be "economically" similar as well as "technologically" similar. (Dkt. No. 710 at 5.) Apple contends that this omission likely caused the jury to view the Qualcomm agreements as comparable solely based on the similar technology. (*Id*.)

Optis argues that Apple cites no authority requiring an instruction on the "economic" aspects of allegedly comparable licenses. (Dkt. No. 717 at 5.) Indeed, the Court instructed the jury that in determining a reasonable royalty, the jury should consider, among other things, "[t]he rates paid by the licensee for the use of other patents comparable to the Patents-in-Suit. Comparable license agreements include those covering the use of the claimed invention or similar technology." (Dkt. No. 94 at 36:4–14.) At trial, there was abundant evidence of license agreements and testimony, both on direct and cross-examination, about their alleged "comparability" or "noncomparability." (*See, e.g.*, Dkt. No. 692 at 150:59, 175:2–176:18, 177:1–180:17, 234:4–235:11, 238:6–16, 282:15–293:12; Dkt. No 693 at 143:11–167:19.) The jury was entitled to weigh the testimony of the parties' experts on comparability of license agreements in calculating a reasonable royalty without any instruction beyond the Court's standard language. Apple's argument to the contrary does not warrant granting a new trial.

***xvi. New Trial: SSPPU Jury Instructions***

Apple argues that its damages theory relied on the smallest salable patent practicing unit (the "SSPPU"), that it was prejudicial to deny Apple's request regarding a jury instruction on the same, and that the jury was therefore not correctly instructed. (Dkt. No. 699 at 14.) Apple contends that even when using a comparable license analysis, if the patented features are embodied in a component, the damages must still be apportioned to the component rather than the overall product—the SSPPU. (Dkt. No. 710 at 5.)

Optis asserts that Apple's proposed SSPPU instruction was contrary to law and properly rejected, especially given that there was no "conflicting" instruction in this case. (Dkt. No. 706 at 14.) Moreover, Optis contends that there was no evidentiary basis for Apple's SSPPU instruction because Apple's corporate representative testified that [redacted] (*Id.*) Optis also contends that Apple's proposed SSPPU instruction mirrored the *per se* rule rejected in *Commonwealth Sci. & Indus. Research Org. v. Cisco Sys., Inc*. and thus was properly rejected here. (Dkt. No. 717 at 5 (citing 809 F.3d 1295, 1303 (Fed. Cir. 2015)).) Apple sought a jury instruction stating that the damages award "should [be] base[d]…on the smallest salable patent-practicing unit" where the "product includes significant non-infringing components." (Dkt. No 677 at 24.) The Federal Circuit held in *Commonwealth* that it would be "untenable" for "all damages models to begin with the smallest salable patent-practicing unit." *Commonwealth*, 809 F.3d at 1303–04. Accordingly, the Court's denial of Apple's proposed SSPPU jury instruction is consistent with Federal Circuit precedent and Apple's argument to the contrary does not compel granting a new trial.

### *xvii. New Trial: Use of Profits Jury Instructions*

Apple argued that the Court instructed the jury, over Apple's objection, that evidence of actual profits of any infringer may be used to determine anticipated profits at the time of negotiation and the Court declined to instruct that a defendant's profits are irrelevant. (Dkt. No. 699 at 14–15.) Apple argues that the jury was thus under the mistaken impression that Apple's profits (actual or anticipated) were relevant to determining a FRAND rate regardless of whether those profits were related to the claimed inventions. (*Id*. at 15.) Apple also contends that there is no authority to indicate that Apple's profit share across the cellular industry was relevant to determining damages and the Court's "refusal" to give Apple's proposed instruction was prejudicial. (Dkt. No. 710 at 5.)

Optis contends that this instruction was proper as directly relevant to the non-discrimination prong of a FRAND royalty and that the Court previously explained the same to the parties. (Dkt. No. 706 at 15 (citing Dkt. No. 692 at 148:12–14).)

This Court has already held that "the profits and the income related to the accused devices directly relate" to what a FRAND royalty would be. (Dkt. No. 692 at 148:12–14.) When instructing the jury, the Court explicitly stated that "[a]lthough evidence of the actual profits of an infringer may be used to determine the anticipated profits at the time of the hypothetical negotiation, the royalty may not be limited to increased based on the actual profits made." (Dkt. No. 694 at 34:2–5.) As to Apple's concern that the Court did not provide a curative instruction that Optis "could not seek disgorgement of those profits" (Dkt. No. 699 at 14–15), the jury was properly instructed on the applicable law, and a "jury is presumed to follow the [C]ourt's instructions." *Datatreasury*, 2010 U.S. Dist. LEXIS 143587, at *15. Further, the Court instructed the jury that it "must not include any additional amount [of damages] for the purposes of punishing Apple or setting an

example." (Dkt. No. 694 at 32:22–33:1.) Accordingly, Apple's proposed jury instruction regarding use of profits was properly denied and does not warrant a new trial.

##### ***xviii. New Trial: Georgia-Pacific Factor 9 Jury Instructions***

Apple argued that both parties asked for an instruction on *Georgia-Pacific* factor 9 ("the utility and advantages of the patent property over the old modes or devices, if any, that had been used for working out similar results") but the Court denied the same. (Dkt. No. 699 at 15.) Apple argues that this was prejudicial. (*Id.*) Apple also argues that Optis proposed the instruction that "they now suggest was improper." (Dkt. No. 710 at 5.) Optis contends that the Court modified factor 9 for the FRAND context and was thus proper and consistent with *Ericsson*. (Dkt. No. 706 at 15 (citing *Ericsson*, 773 F.3d at 1231).)

Optis's briefing does not suggest that the Court's instruction was "improper," as Apple alleges. (Dkt. No. 710 at 5.) Rather, Optis maintains that the Court's modification of the proposed instructions on *Georgia-Pacific* factor 9 was proper. (Dkt. No. 706 at 15.) Ericsson instructs that certain *Georgia-Pacific* factors "need to be adjusted for [F]RAND-encumbered patents" and for "SEP patents generally." *Ericsson*, 773 F.3d at 1231. The Court followed this precedent in instructing the jury on the *Georgia-Pacific* factors and such does not warrant a new trial.

##### ***xix. New Trial: Remittitur (in the Alternative)***

Apple argues that the only correct damages opinion was offered by their expert, Dr. Perryman, and that damages should be remitted to his calculation of $5.1–6.4 million. (Dkt. No. 699 at 15.)

Optis argues that Apple's argument is merely a "placeholder" without explanation or supporting evidence as to why Dr. Perryman's opinion was the only "correct" opinion, and such must be rejected. (Dkt. No. 706 at 15.) Optis also maintains that Apple's disagreement with Optis

about the damages award does not render Dr. Perryman's calculation the "only proper" theory. (Dkt. No. 717 at 5.)

Apple argues that it dedicated the bulk of its post-trial motions to describing the "flawed methodology" and "evidentiary insufficiency" of Optis's damages theories, thus making it "abundantly clear why Apple viewed Dr. Perryman's as the only valid damages range." (Dkt. No. 710 at 5.) However, how Apple viewed Dr. Perryman's testimony is not the issue before the Court.

The jury heard damages evidence and testimony from both parties and was entitled to weigh such evidence in coming to its final damages decision. To the extent Apple disparages the methodology of all experts other than Dr. Perryman, such is another late *Daubert* attack which is now rejected. Moreover, the jury heard evidence from Dr. Perryman and Mr. Kennedy on the issue of damages. The fact that the jury did not award Dr. Perryman's number (or Mr. Kennedy's for that matter) cannot somehow be transformed into a conclusion that Dr. Perryman's opinion was the "only" correct opinion. Remittitur of the jury's damages award is not warranted.

## IV. Supplemental Briefing on *Wi-LAN* (Dkt. Nos. 730, 731)

Pursuant to a Notice of Supplemental Authority filed by Apple (Dkt. No. 725) contending that the Federal Circuit's decision in *Apple Inc. v. Wi-LAN Inc.*, 25 F.4th 960 (Fed. Cir. 2022) ("*Wi-LAN*") supported its argument, the Court ordered the parties to file supplemental briefing as to the impact of the *Wi-LAN* decision on Apple's pending New Trial and JMOL Motions. (Dkt. No. 785 at 1.)

Apple argues that the Federal Circuit's decision in *Wi-LAN* confirms that JMOL or a new trial is warranted based on Mr. Kennedy's "improper reliance on the Qualcomm agreements." (Dkt. No. 730 at 1.) Apple notes that it was Mr. Kennedy's opinion that was at issue in *Wi-LAN* and was challenged based on Mr. Kennedy's alleged "fail[ure] to properly apportion the

comparable licenses to reflect the value of the asserted patents." (*Id.*) In *Wi-LAN*, Apple states that it did not challenge whether the license agreements that Mr. Kennedy relied upon were "comparable" as it did with the Qualcomm agreements here. (*Id.*) Apple explains that in *Wi-LAN*, the court found that Mr. Kennedy improperly treated certain patents as "key patents," a finding which the Court determined was "untethered to the facts of the case." (*Id.* at 2.) Apple contends that the finding in *Wi-LAN* compels the same finding here because Mr. Kennedy [redacted] (*Id.* at 2.) Apple argues that Mr. Kennedy did so [redacted] (*Id.*) In doing so, Apple contends that Mr. Kennedy ignored the [redacted] (*Id.* at 3.) As a result, Apple argues that Mr. Kennedy's opinion improperly assumed that [redacted] (*Id.*) Apple further argues, as it did in its earlier briefing, that [redacted] (*Id.* at 4.)

Optis contends that *Wi-LAN* "did not reject the methodological assumption that there are 'key patents' that can drive the value of a license that includes other patents," but instead "focused on the absence of substantial evidence" that the patents asserted in that case were "key" to other comparable agreements. (Dkt. No. 731 at 1.) Optis argues that unlike in *Wi-LAN*, Mr. Kennedy did not apply a comparable license approach in this case, which renders *Wi-LAN* inapplicable. (*Id.*)

Instead, Optis contends that Mr. Kennedy's analysis was based solely on the "incremental value attributable to the patented features (*i.e.*, increases in upload or download speed)" for the asserted patents based on comparisons done by Optis's technical experts. (*Id.*) Optis repeats the argument that Mr. Kennedy [redacted] (*Id.* at 2.) Further, Optis contends that Mr. Kennedy's original royalty rate calculation was [redacted] (*Id.*) Optis asserts that Mr. Kennedy simply [redacted] on his own calculation and contends that Apple's expert, Dr. Perryman, did the same, but with an admittedly noncomparable Samsung license. (*Id.* at 2–4.) Optis also contends that it is Dr. Perryman's analysis, *not* Mr. Kennedy's, that fails under *Wi-LAN* because Dr. Perryman did not perform a "technical analysis of any of the patents in any of the licenses" in comparing the "differences in the technologies and economic circumstances of the contracting parties." (*Id.* at 5 (citing *Wi-LAN*, 25 F.4th at 971).)

The Court does not find that the decision in *Wi-LAN* should change any of the findings reached by the jury in the second trial on damages. The damages methodology at issue in *Wi-LAN* was different from that used by Mr. Kennedy here. *See generally Wi-LAN*, 25 F.4th at 972-73 ("Mr. Kennedy first sought to establish that, in practice, only a handful of valuable patents drive the royalty rate for a license, and the rest of the portfolio is included for a marginal upcharge. . . . Mr. Kennedy treated the asserted patents as the key patents."). Here, in contrast, Mr. Kennedy used the Qualcomm license agreement [redacted]

[redacted] (Dkt. No. 731 at 2.) Mr. Kennedy [redacted] based on [redacted] (*Id.*) (emphasis added). Thus, *Wi-LAN*, under the particular facts of this case, is not controlling on this issue, nor does it warrant an award of JMOL or a new trial.

## V. Conclusion

For the reasons set forth herein, Apple's Motion for a New Trial (Dkt. No. 699) and Motion for Judgment as a Matter of Law (Dkt. No. 799) are **DENIED**.

**So ORDERED and SIGNED this 17th day of May, 2022.**

RODNEY GILSTRAP
UNITED STATES DISTRICT JUDGE

U 7718051

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

April 18, 2019

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF:

U.S. PATENT: *8,019,332*
ISSUE DATE: *September 13, 2011*

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

R GLOVER
Certifying Officer

Plaintiffs' Exhibit
**PX 0002**
2:19-cv-00066-JRG

US008019332B2

# (12) United States Patent
**Lee et al.**

(10) **Patent No.:** **US 8,019,332 B2**
(45) **Date of Patent:** **Sep. 13, 2011**

(54) **METHOD FOR TRANSMITTING AND RECEIVING CONTROL INFORMATION THROUGH PDCCH**


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(73) Assignee: **LG Electronics Inc.**, Seoul (KR)



( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/963,570**

(22) Filed: **Dec. 8, 2010**

(65) **Prior Publication Data**

US 2011/0080888 A1 Apr. 7, 2011

**Related U.S. Application Data**

(63) Continuation of application No. 12/252,270, filed on Oct. 15, 2008, now Pat. No. 7,873,004.

(60) Provisional application No. 61/029,576, filed on Feb. 19, 2008, provisional application No. 61/037,000, filed on Mar. 17, 2008.

(30) **Foreign Application Priority Data**

Jul. 15, 2008 (KR) ........................ 10-2008-0068633

(51) **Int. Cl.**
*H04W 4/00* (2009.01)

(52) **U.S. Cl.** ..................... **455/422.1**; 455/522; 455/423; 370/329; 370/336

(58) **Field of Classification Search** .................. 455/422, 455/423; 370/329, 336

See application file for complete search history.


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*Primary Examiner* — David Q Nguyen

(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey


(57) **ABSTRACT**


A method for efficiently transmitting and receiving control information through a Physical Downlink Control Channel (PDCCH) is provided. When a User Equipment (UE) receives control information through a PDCCH, the received control information is set to be decoded in units of search spaces, each having a specific start position in the specific subframe. Here, a modulo operation according to a predetermined first constant value (D) is performed on an input value to calculate a first result value, and a modulo operation according to a predetermined first variable value (C) corresponding to the number of candidate start positions that can be used as the specific start position is performed on the calculated first result value to calculate a second result value and an index position corresponding to the second result value is used as the specific start position. Transmitting control information in this manner enables a plurality of UEs to efficiently receive PDCCHs without collisions.


**20 Claims, 14 Drawing Sheets**

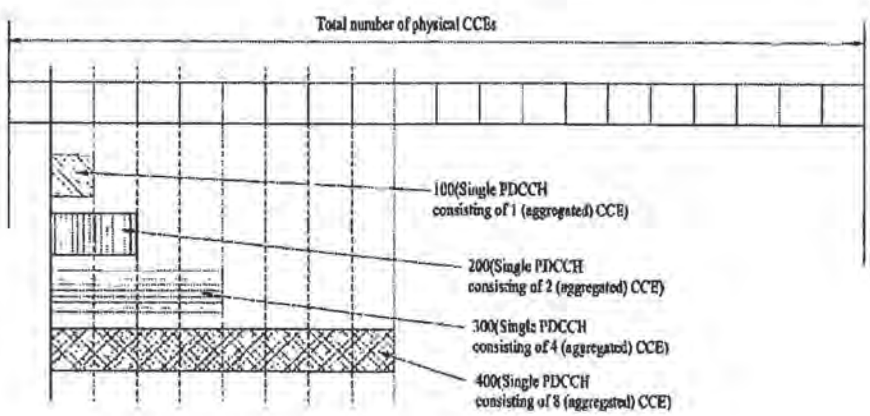

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FIG. 1

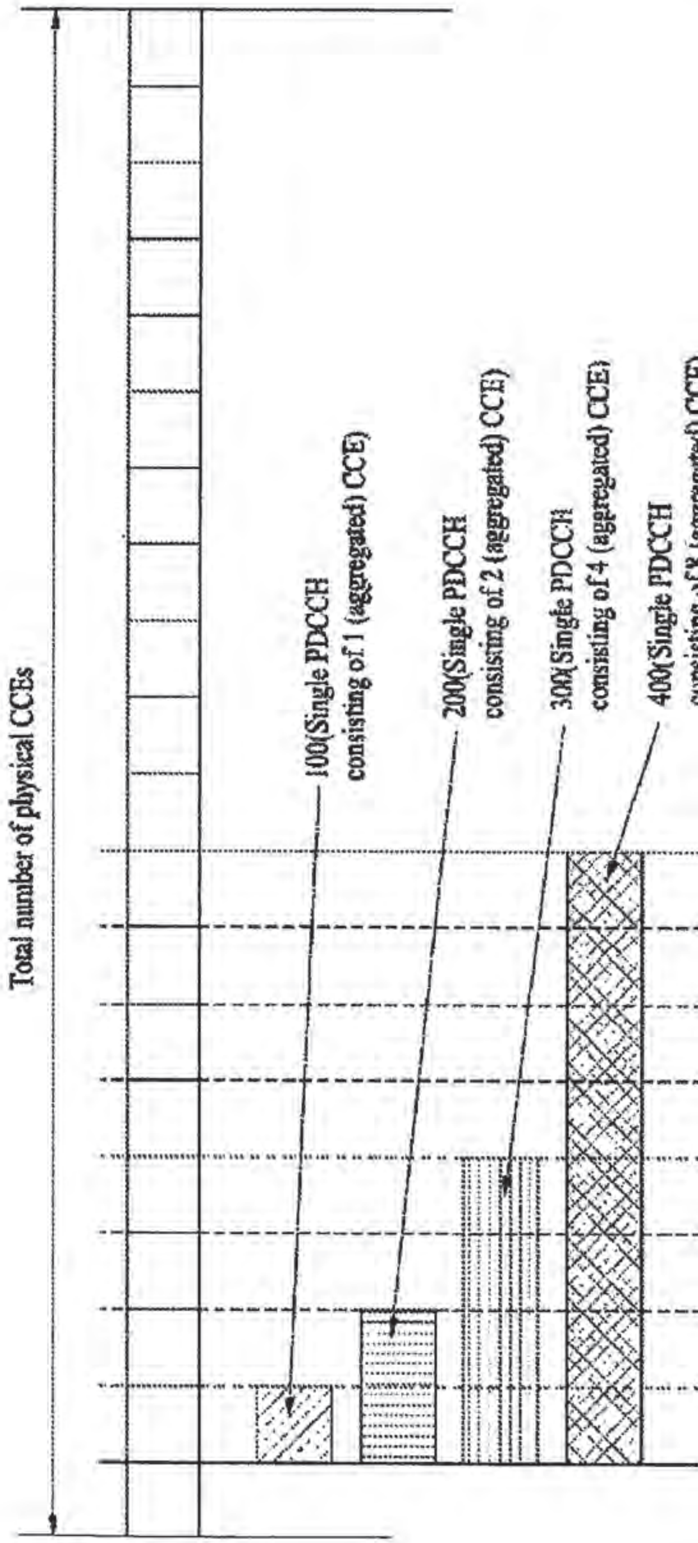

Total number of physical CCEs
100(Single PDCCH consisting of 1 (aggregated) CCE)
200(Single PDCCH consisting of 2 (aggregated) CCE)
300(Single PDCCH consisting of 4 (aggregated) CCE)
400(Single PDCCH consisting of 8 (aggregated) CCE)

FIG. 2

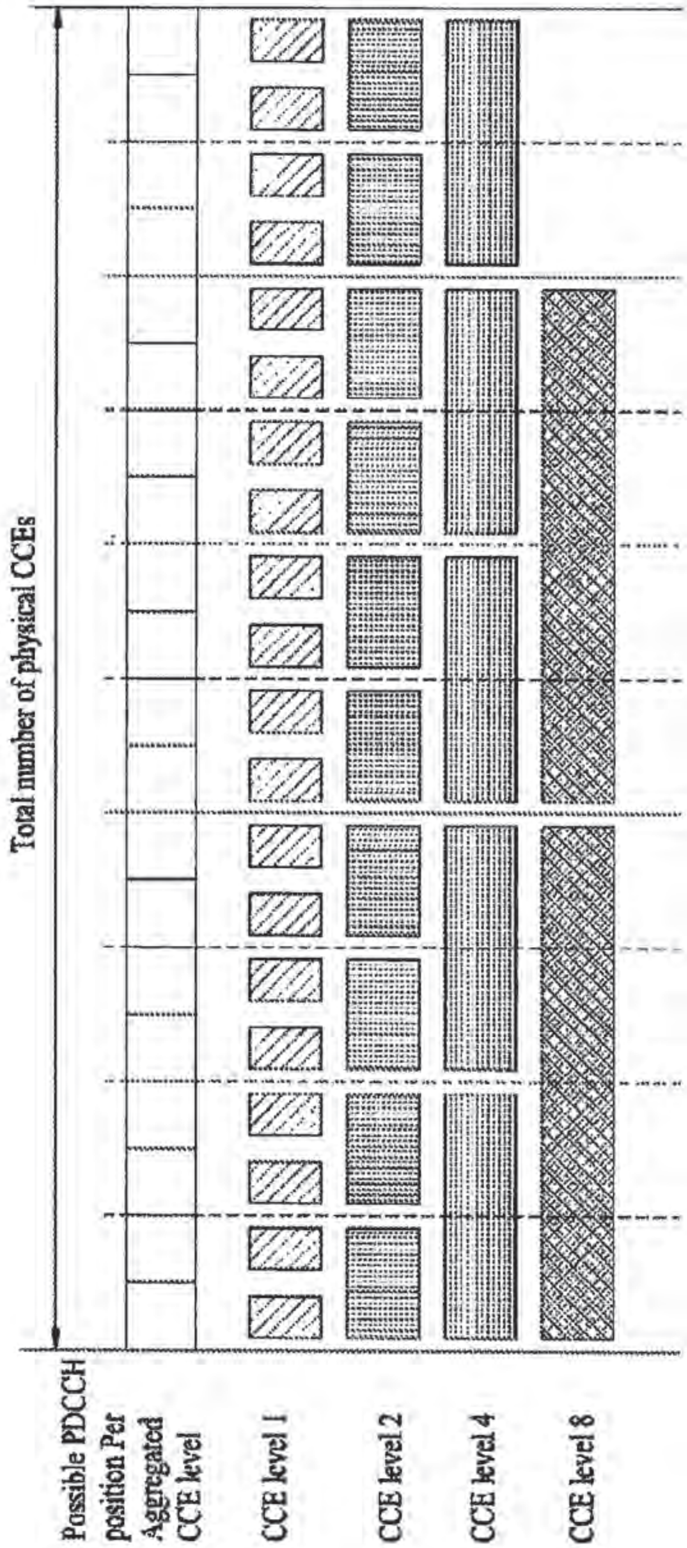

Total number of physical CCEs
Possible PDCCH position Per Aggregated CCE level
CCE level 1
CCE level 2
CCE level 4
CCE level 8

FIG. 3

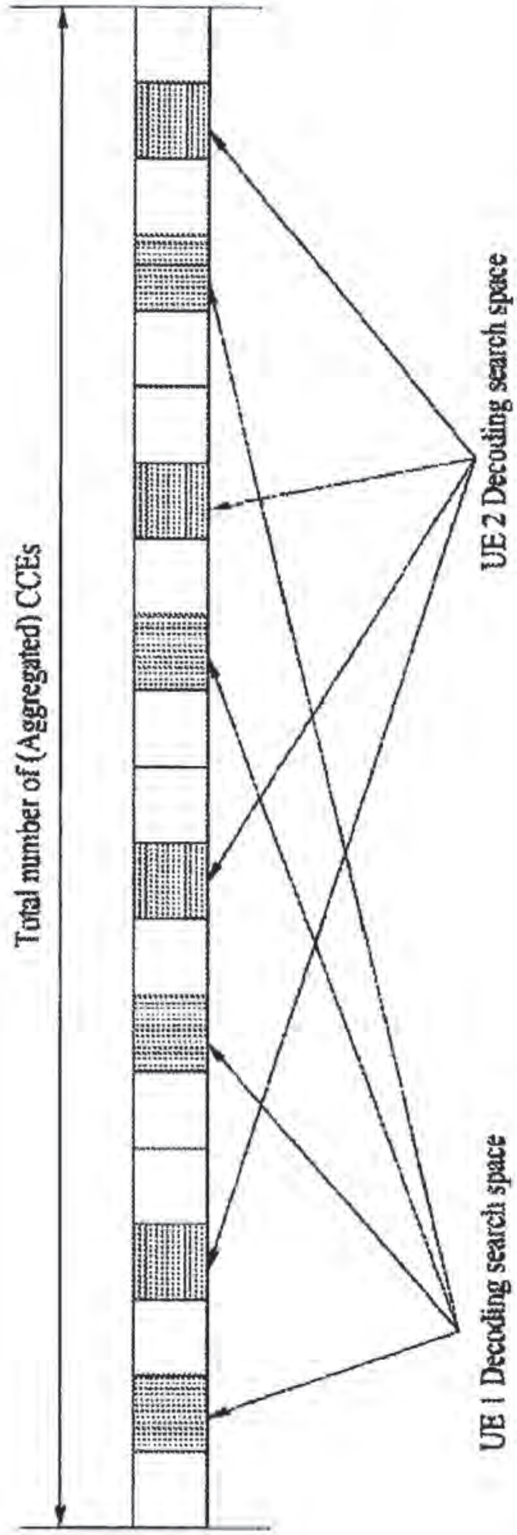

Total number of (Aggregated) CCEs
UE 2 Decoding search space
UE 1 Decoding search space

FIG. 4

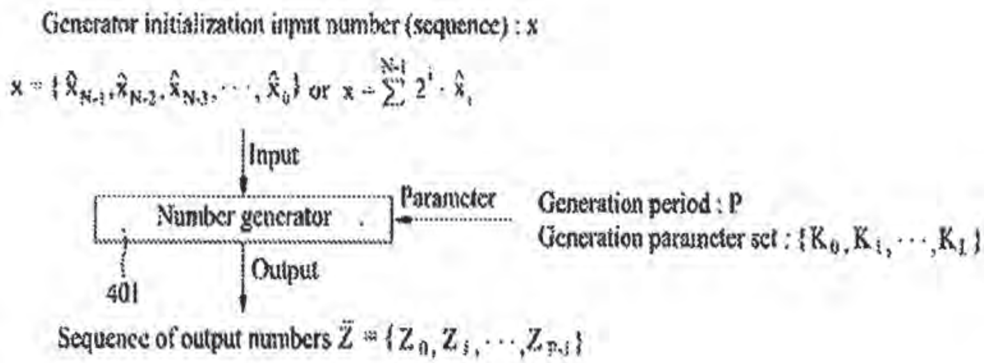

Generator initialization input number (sequence) : x
$x = \{\hat{x}_{N-1}, \hat{x}_{N-2}, \hat{x}_{N-3}, \cdots, \hat{x}_0\}$ or $x = \sum^{N-1} 2^i \cdot \hat{x}_i$
Input
Number generator
Parameter
Generation period : P
Generation parameter set : $\{K_0, K_1, \cdots, K_I\}$
401
Output
Sequence of output numbers $\bar{Z} = \{Z_0, Z_1, \cdots, Z_{P-1}\}$

FIG. 5

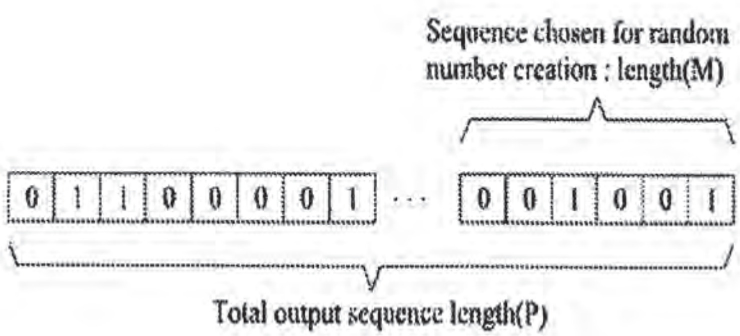

Sequence chosen for random number creation : length(M)
0 1 1 0 0 0 0 1 ... 0 0 1 0 0 1
Total output sequence length(P)

FIG. 6

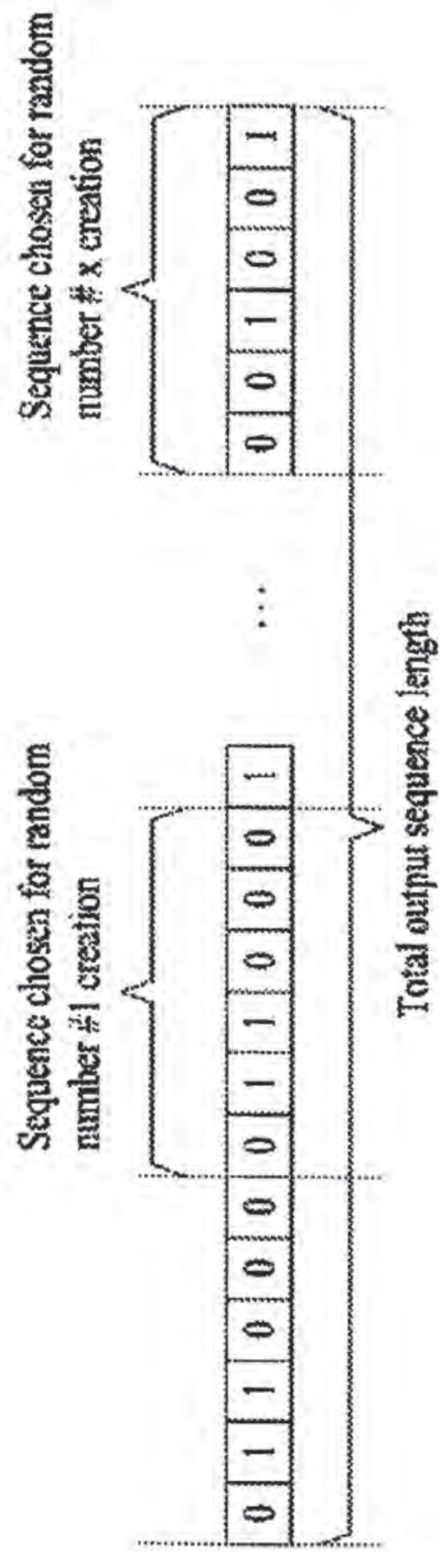

Sequence chosen for random number # x creation
Sequence chosen for random number #1 creation
Total output sequence length

FIG. 7

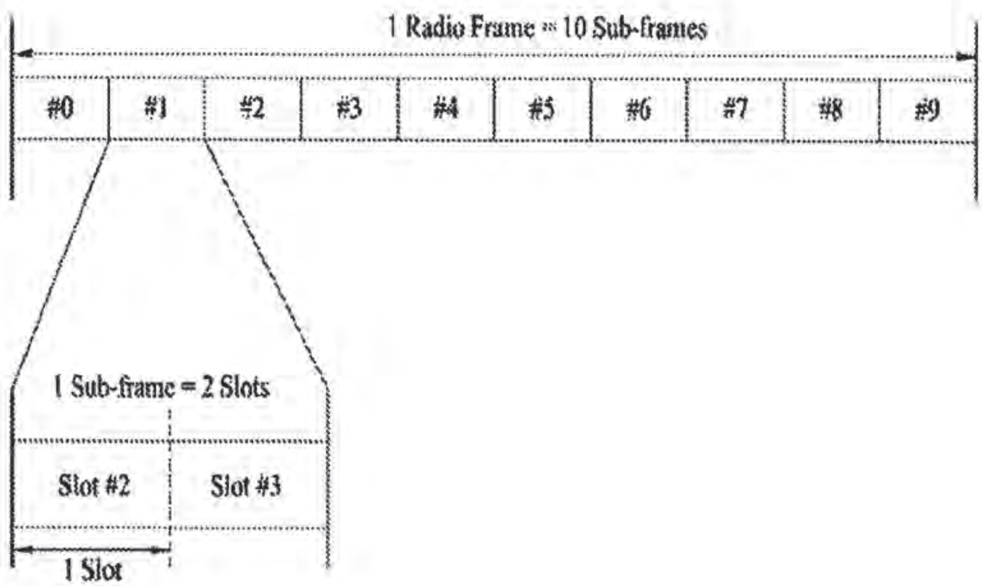

1 Radio Frame = 10 Sub-frames
#0
#1
#2
#3
#4
#5
#6
#7
#8
#9
1 Sub-frame = 2 Slots
Slot #2
Slot #3
1 Slot

FIG. 8

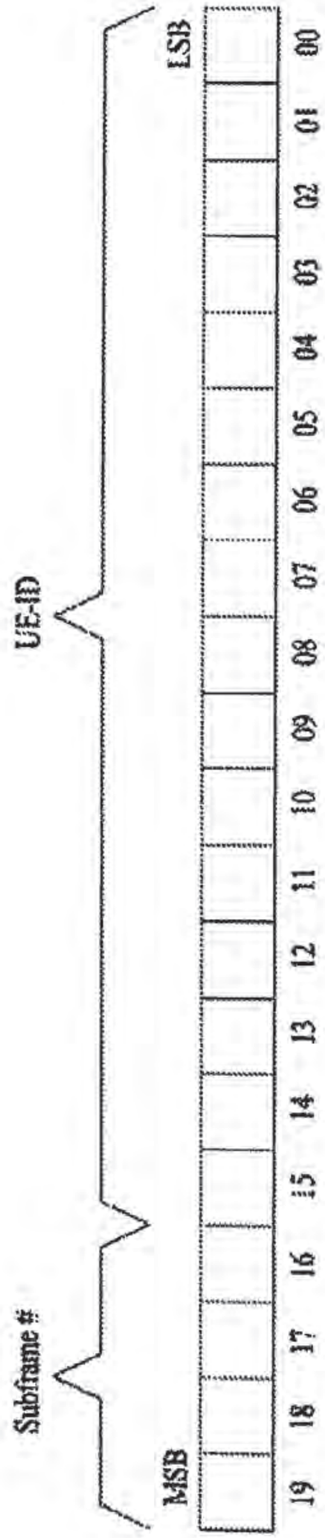

LSB
UE-ID
Subframe #
MSB
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19

FIG. 9

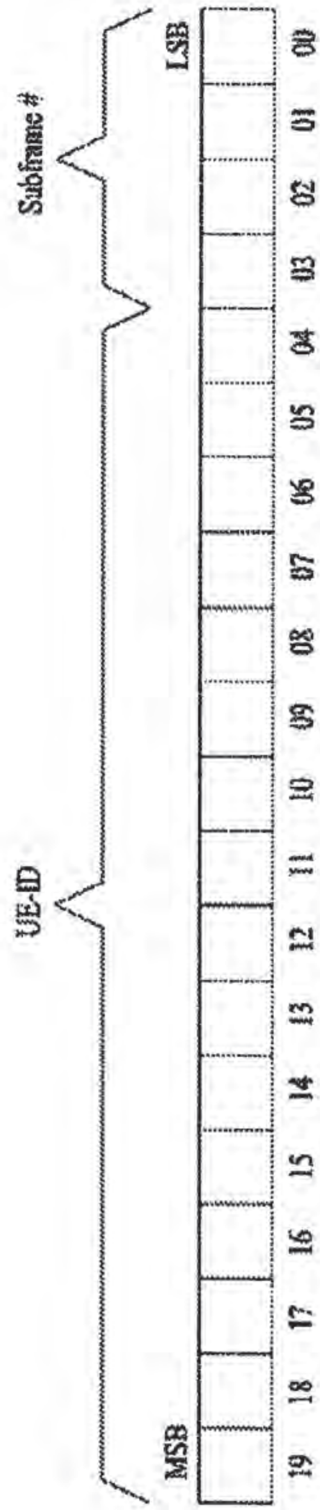

Subframe #
UE-ID
LSB
MSB
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19

FIG. 10

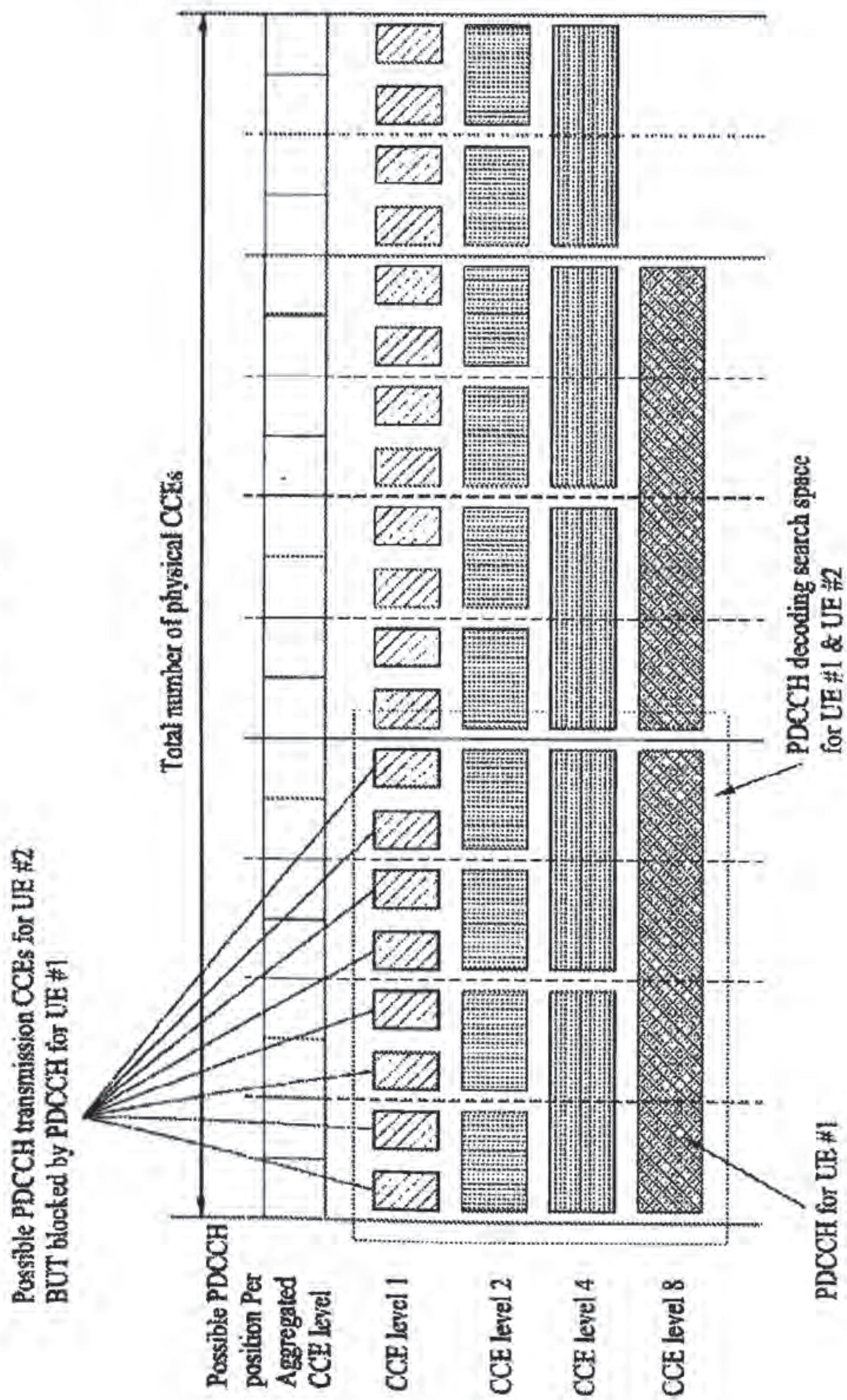

Possible PDCCH transmission CCEs for UE #2
BUT blocked by PDCCH for UE #1
Total number of physical CCEs
Possible PDCCH position Per Aggregated CCE level
CCE level 1
CCE level 2
CCE level 4
CCE level 8
PDCCH decoding search space for UE #1 & UE #2
PDCCH for UE #1

FIG. 11

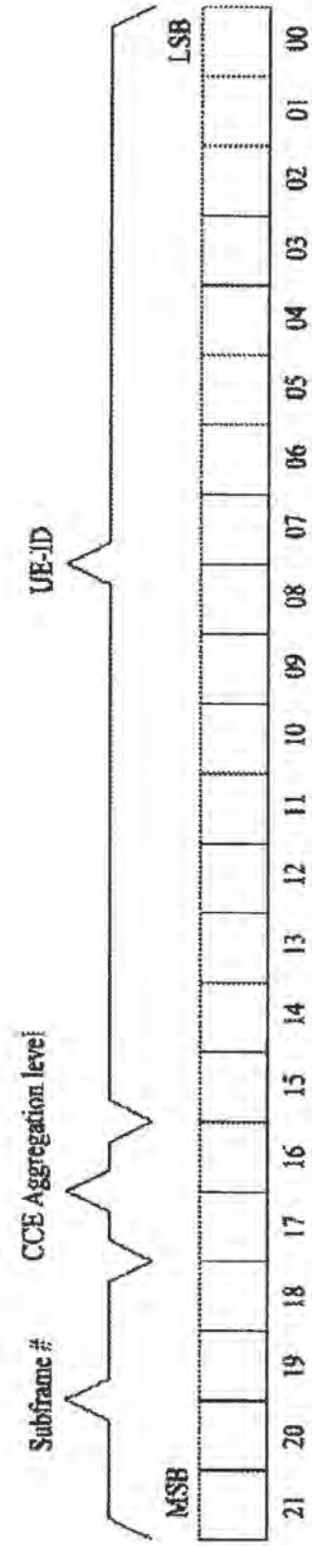
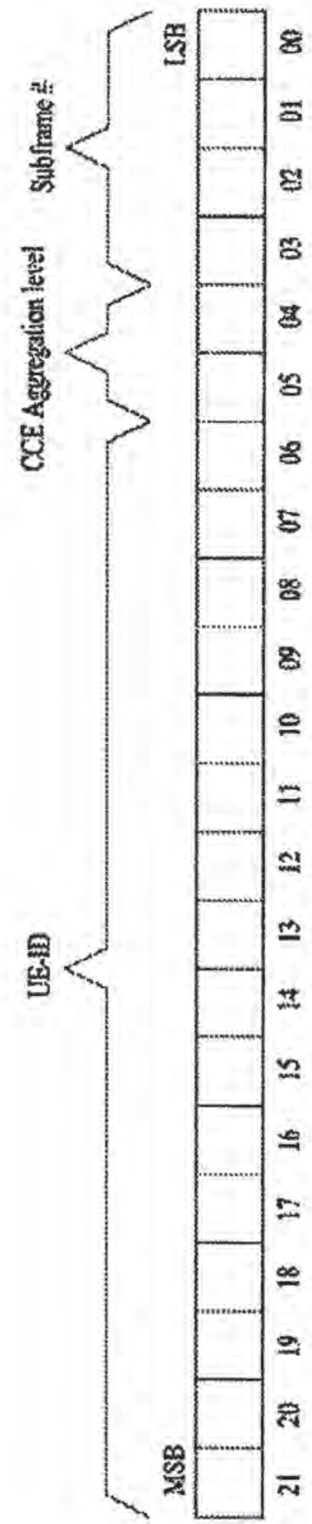

Subframe #
CCE Aggregation level
UE-ID
MSB
LSB
21 20 19 18 17 16 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 00

FIG. 12



Subframe #
CCE Aggregation level
UE-ID
LSB
MSB
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
21

FIG. 13

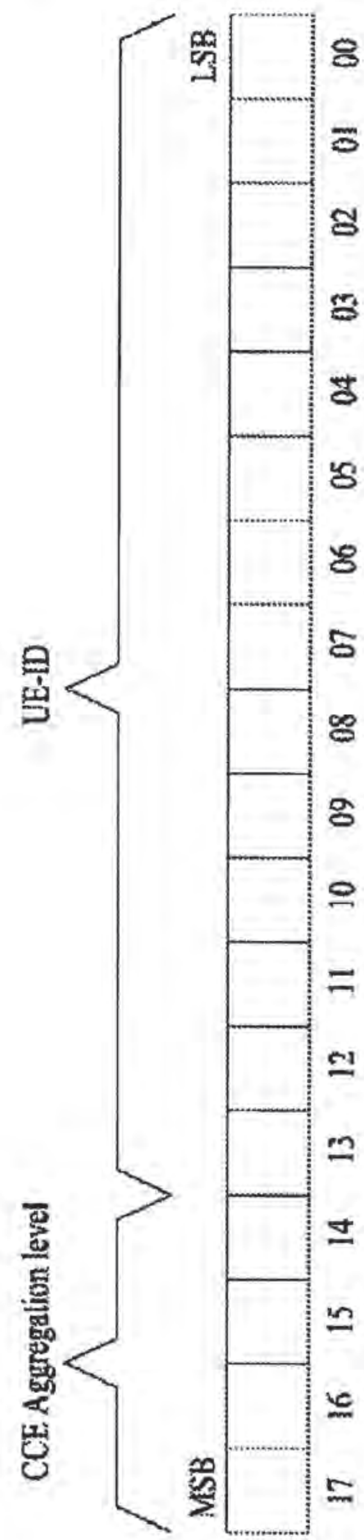

CCE Aggregation level
UE-ID
MSB
LSB
17 16 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 00

FIG. 14

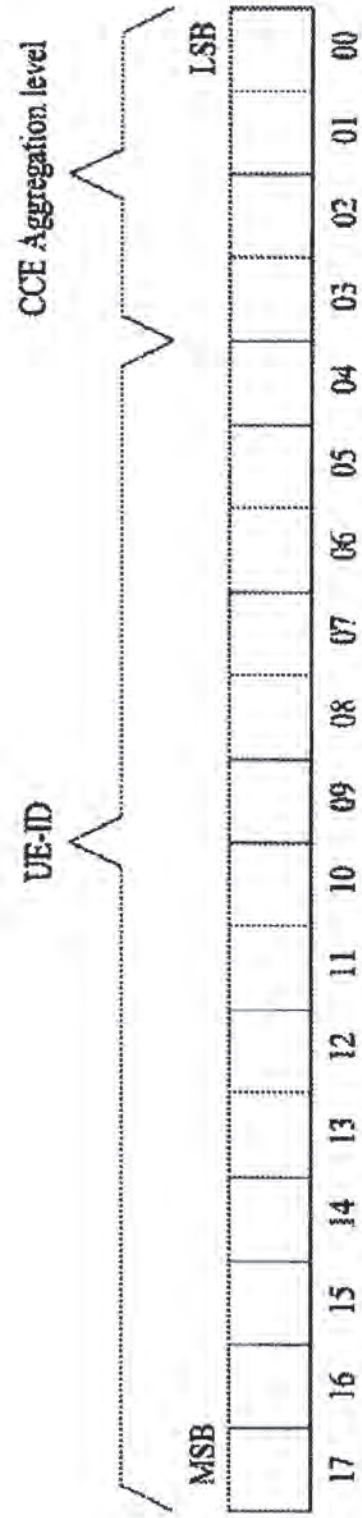
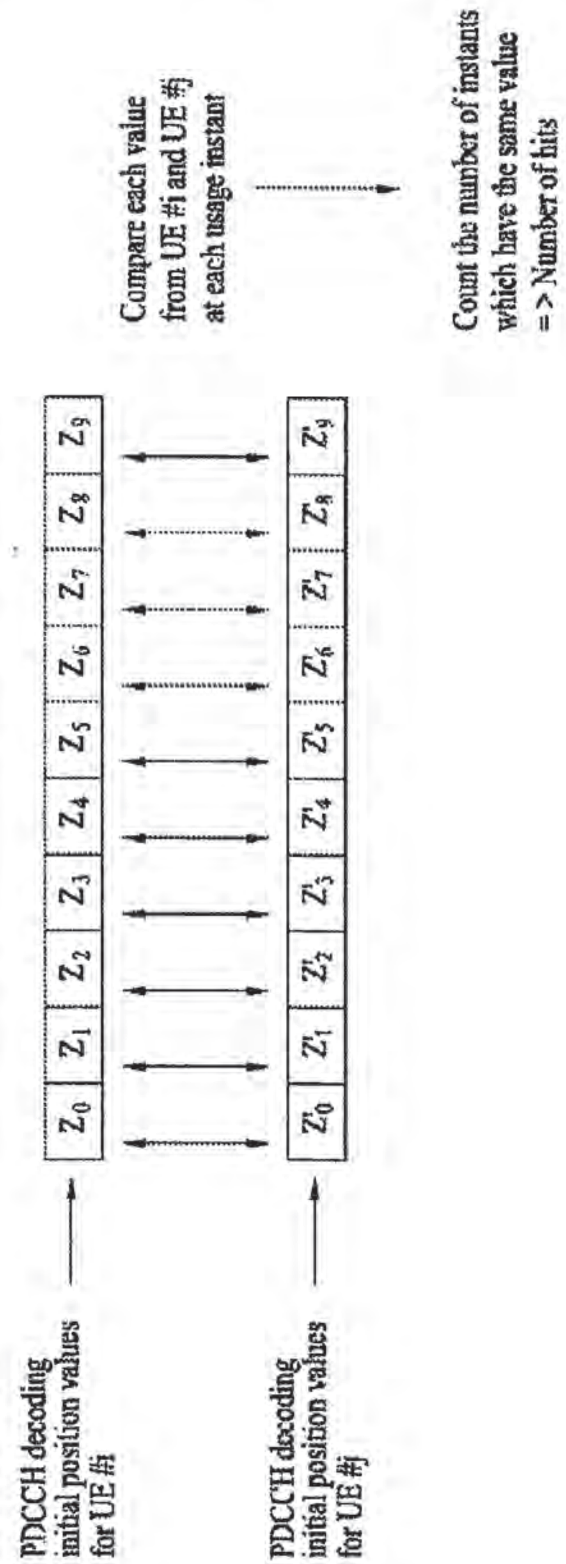

CCE Aggregation level
UE-ID
LSB
MSB
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17

FIG. 15


PDCCH decoding initial position values for UE #i
PDCCH decoding initial position values for UE #j
$Z_0$ $Z_1$ $Z_2$ $Z_3$ $Z_4$ $Z_5$ $Z_6$ $Z_7$ $Z_8$ $Z_9$
$Z'_0$ $Z'_1$ $Z'_2$ $Z'_3$ $Z'_4$ $Z'_5$ $Z'_6$ $Z'_7$ $Z'_8$ $Z'_9$
Compare each value from UE #i and UE #j at each usage instant
Count the number of instants which have the same value => Number of hits

# METHOD FOR TRANSMITTING AND RECEIVING CONTROL INFORMATION THROUGH PDCCH

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 12/252,270, filed on Oct. 15, 2008, now U.S. Pat. No. 7,873,004, which claims the benefit of the Korean Patent Application No. 10-2008-0068633, filed on Jul. 15, 2008, which are hereby incorporated by reference as if fully set forth herein. U.S. application Ser. No. 12/252,270 also claims the benefit of U.S. Provisional Application Ser. Nos. 61/029,576, filed on Feb. 19, 2008 and 61/037,000, filed on Mar. 17, 2008, the contents of which are hereby incorporated by reference herein in their entirety.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to mobile communication technologies, and more particularly, to a method for efficiently transmitting and receiving control information through a Physical Downlink Control Channel (PDCCH).

2. Discussion of the Related Art

The following description can be applied to various mobile communication methods. However, a description will be given, particularly with reference to Third Generation Partnership Project Long Term Evolution (3GPP LTE) technologies.

3GPP LTE is a project for improving the UMTS mobile station standard to cope with future technology development in the Third Generation Partnership Project (3GPP). 3GPP LTE has evolved to Release 8 which is an improved version of the 3GPP standard.

In the 3GPP LTE communication system, various channels are defined for uplink and downlink in the physical layer used in actual signal transmission. For example, a Physical Uplink Shared Channel (PUSCH), a Physical Uplink Control Channel (PUCCH), and a Physical Random Access Channel (PRACH) are defined as uplink physical channels, and a Physical Downlink Shared Channel (PDSCH), a Physical Multicast Channel (PMCH), a Physical Broadcast Channel (PBCH), a Physical Control Format Indicator Channel (PCFICH), a Physical Downlink Control Channel (PDCCH), and a Physical Hybrid ARQ (HARQ) Indicator Channel (PHICH) are defined as downlink physical channels. In the following description, the word "physical" will be omitted for ease of explanation unless the omission causes confusing.

Among the various channels, the PDCCH serves to transmit scheduling allocation control information and other control information. In a cellular communication system in which one base station (or Node-B) controls a plurality of User Equipments (UEs) or (mobile stations), multiple UEs can receive control information through a PDCCH transmitted from the base station. Here, since there is a limit to the number of PDCCHs that the base station can transmit at once, the base station does not previously allocate different PDCCHs to each UE but transmits control information through an arbitrary PDCCH to an arbitrary UE at each time. Thus, the UE determines whether or not control information received through the PDCCH belongs to the UE based on a UE identifier included in the PDCCH. At each time, the UE performs decoding on each of a plurality of PDCCHs (for a plurality of possible PDCCH formats) and receives, when it is



determined that the PDCCH corresponds to the UE, control information included in the PDCCH and operates according to the control information.

However, the number of combinations of PDCCH regions for transmission of control information may be great. Excessive UE processing performance may be required for the UE to decode all PDCCH regions. Accordingly, there is a need to limit PDCCH regions to be decoded by each UE to reduce the number of times the UE performs decoding and thus to reduce power consumption of the UE.

## SUMMARY OF THE INVENTION

An object of the present invention devised to solve the problem lies in providing a technology for efficiently transmitting and receiving control information through a Physical Downlink Control Channel (PDCCH).

Another object of the present invention devised to solve the problem lies in providing a technology for efficiently setting a different start position of a search space for each UE in order to transmit and receive control information to and from each UE through a different search space.

The object of the present invention can be achieved by providing a method for a User Equipment (UE) to receive control information through a Physical Downlink Control Channel (PDCCH), the method including receiving control information from a base station through a PDCCH in units of Control Channel Element (CCE) aggregations, each including at least one CCE in a control region of a specific subframe; and decoding the received control information in units of search space in the specific subframe, wherein a modulo operation according to a predetermined first constant value (D) is performed on an input value to calculate a first result value, and a modulo operation according to a predetermined first variable value (C) defined by the equation of

$$C=\text{floor}(N_{CCE}/L_{CCE})$$

is performed on a value corresponds to the calculated first result value to calculate a second result value and the search space starts with an index position corresponding to the second result value (where $N_{CCE}$ represents the total number of CCEs in the specific subframe, and $L_{CCE}$ is the number of CCEs included in the CCE aggregation, and floor(x) is a largest integer that is equal to or less than x).

In another aspect of the present invention, provided herein is a method for a base station to transmit control information through a Physical Downlink Control Channel (PDCCH), the method including transmitting control information for a specific User Equipment (UE) through a PDCCH in units of Control Channel Element (CCE) aggregations, each including at least one CCE in a control region of a specific subframe, wherein the control information for the specific UE is transmitted in units of search space in the specific subframe, and wherein a modulo operation according to a predetermined first constant value (D) is performed on an input value to calculate a first result value, and a modulo operation according to a predetermined first variable value (C) defined by the equation of

$$C=\text{floor}(N_{CCE}/L_{CCE})$$

is performed on a value corresponds to the calculated first result value to calculate a second result value and the search space starts with an index position corresponding to the second result value.

In the above methods, preferably, the first constant value (D) is predetermined to be higher than the first variable value (C).

In addition, it may be advantageous that the input value for a "k+1"th subframe is set to correspond to the first result value for a "k"th subframe, where "k" is a non-negative integer.

On the other hand, in the above methods, an identification information value of the UE may be used for the input value for a 1st subframe.

In addition, the first result value may be calculated by multiplying the input value by a predetermined second constant value (A), adding a predetermined third constant value (B), which result in a intermediate value, and performing the modulo operation according to the first constant value (D) on the intermediate value.

In this case, preferably, the first constant value (D), the second constant value (A), and the third constant value (B) are 65537, 39827, and 0, respectively.

In an embodiment of the present invention, when the specific subframe is the "k"th subframe, the first constant value is "D", and the first constant value is "C", the search space starts with a specific start position $Z_k$ in the "k"th subframe, the specific start position $Z_k$ in the "k"th subframe is set as an index position corresponding to a value determined by $Z_k=[(A \cdot y_k+B) \bmod D] \bmod C$ and $y_k=(A \cdot y_{k-1}+B) \bmod D$, where A and B denote predetermined constant values and "k" denotes a subframe index.

In this case, the first constant value "D" may be 65537, and the predetermined constant values "A" and "B" may be 39827 and 0, respectively.

Here, the index position corresponding to the determined value may correspond to a start position of a CCE aggregation corresponding to the determined value under the assumption that indices are assigned on a CCE aggregation basis. According to the embodiments of the present invention described above, it is possible to efficiently transmit and receive control information through a Physical Downlink Control Channel (PDCCH).

Specifically, a different start position of a search space can be set for each UE so that control information can be transmitted and received to and from each UE through a different search space.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIG. **1** illustrates an example of a CCE aggregation through which one PDCCH can be transmitted.

FIG. **2** illustrates all possible decoding regions that the UE needs to attempt to decode taking into consideration the CCE aggregation level.

FIG. **3** illustrates an example wherein two different UEs have different decoding regions under a specific CCE aggregation level condition.

FIG. **4** illustrates the principle of a generator that generates identification dependent randomization numbers according to an embodiment of the present invention.

FIGS. **5** and **6** illustrate an example wherein a part of a binary sequence generated by the generator is selected as an initial value according to an embodiment of the present invention.

FIG. **7** illustrates a frame structure in the 3GPP LTE system for explaining an example in which a communication system operates at regular intervals

FIGS. **8** and **9** illustrate a method for creating an initial value used to generate a start position of a PDCCH search space using a UE ID and a subframe number according to an embodiment of the present invention.

FIG. **10** illustrates an example wherein one of two UEs having different CCE aggregation levels fails to receive a PDCCH destined for the UE due to a PDCCH destined for the other UE.

FIGS. **11** and **12** illustrate examples where a UE ID, a subframe number, and a CCE aggregation level are used to create an initial value according to an embodiment of the present invention.

FIGS. **13** and **14** illustrate examples where an initial value used to calculate a start position of a PDCCH search space is created using a UE ID and a CCE aggregation level according to an embodiment of the present invention.

FIG. **15** illustrates the concept of the number of hits used for determining performance when parameter values are calculated according to an embodiment of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention with reference to the accompanying drawings. The detailed description, which will be given below with reference to the accompanying drawings, is intended to explain exemplary embodiments of the present invention, rather than to show the only embodiments that can be implemented according to the invention. The following detailed description includes specific details in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without such specific details.

In some instances, known structures and devices are omitted or are shown in block diagram form, focusing on important features of the structures and devices, so as not to obscure the concept of the present invention. The same reference numbers will be used throughout this specification to refer to the same or like parts.

When a UE decodes all PDCCH regions, the complexity of the UE and battery consumption are increased. Therefore, it is necessary to specify a PDCCH decoding region for each UE. To accomplish this, there is a need to study in more detail a resource space through which the PDCCH is transmitted.

A PDCCH can be transmitted through a CCE aggregation including one or more Control Channel Elements (CCEs). In addition, a plurality of PDCCHs can be transmitted in one subframe. Here, the term "CCE" refers to a resource unit for transmission of control information, which is a unit corresponding to a specific number of resource elements in the resource space. A detailed description of the concept of the CCE is omitted herein since it is apparent to those skilled in the art.

PDCCH formats can be classified as follows according to the size of a CCE aggregation used for PDCCH transmission as described above.

TABLE 1

| PDCCH format | Number of CCEs |
|---|---|
| 0 | 1 |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |

FIG. 1 illustrates an example of a CCE aggregation through which one PDCCH can be transmitted.

The term "Total Number of CCEs" in FIG. 1 refers to the number of CCEs included in one subframe. However, the number of CCEs included in one subframe may vary according to system requirements. In FIG. 1, a reference numeral "100" denotes a format (PDCCH format 1 in Table 1) in which one PDCCH is transmitted through one CCE, a reference numeral "200" denotes a format (PDCCH format 2 in Table 1) in which one PDCCH is transmitted through 2 CCEs, a reference numeral "300" denotes a format (PDCCH format 3 in Table 1) in which one PDCCH is transmitted through 4 CCEs, and a reference numeral "400" denotes a format (PDCCH format 4 in Table 1) in which one PDCCH is transmitted through 8 CCEs.

That is, as shown in FIG. 1, the size of a CCE aggregation used to transmit one PDCCH may vary depending on channel environments of each UE as shown in FIG. 1. In the following description, the number of CCEs used to transmit one PDCCH will be referred to as a "CCE aggregation level". Thus, when each UE decodes a PDCCH, the UE must determine the size of a decoding region for each CCE aggregation level.

FIG. 2 illustrates all possible decoding regions that the UE needs to attempt to decode taking into consideration the CCE aggregation level.

The number of all possible decoding regions that a UE needs to attempt to decode according to a CCE aggregation level set in the system may be too great as can be seen from FIG. 2. Therefore, it is preferable that a region (a combination of CCE aggregations through which the base station may have transmitted a PDCCH to the UE) that the UE needs to attempt to decode be preset for each UE to limit the number of times the UE has to decode in order to receive a PDCCH.

However, the following must be considered when the PDCCH decoding region is limited. If all different UEs decode the same limited PDCCH decoding region, the base station must transmit PDCCHs to all UEs only through the limited region. Thus, the number of UEs that are simultaneously controllable is restricted since the base station transmits PDCCHs only through the limited region instead of using all available CCEs.

This restriction can be removed if different PDCCH decoding regions (or spaces) are allocated to different UEs. That is, the base station can more efficiently transmit PDCCHs to a number of UEs as the number of UEs which do not have an overlapping PDCCH decoding region increases.

FIG. 3 illustrates an example wherein two different UEs have different decoding regions under a specific CCE aggregation level condition.

In the following description, a region that each UE needs to attempt to decode to receive a PDCCH is referred to as a "search space". In the example of FIG. 3, both a UE 1 and a UE 2 have a CCE aggregation level 1 but have different decoding search spaces. That is, the base station can simultaneously transmit a PDCCH to the UE1 and the UE2 since the decoding search spaces do not overlap as shown in FIG. 3.

The following methods can be employed to set a different search space to each UE.

In the first method, a search space having a different start point (or start position) and a predetermined number of CCEs arranged starting from the start point is allocated to each UE so that each UE has a different search space.

In the second method, a search space having a different start point and a predetermined number of CCEs arranged at regular intervals starting from the start point is allocated to each UE so that each UE has a different search space.

These two methods are similar in that the overlapping PDCCH decoding region can be reduced if the search space of each UE has a different start position. Accordingly, an embodiment of the present invention suggests that different UE search spaces be set to have different start positions as described above to minimize overlapping of search spaces that UEs need to attempt to decode in order to receive a PDCCH. Reducing overlapping of PDCCH decoding regions in this manner increases the number of UEs to which the base station can simultaneously transmit control information through scheduling.

An embodiment of the present invention suggests that a UE identification number that enables identification of each UE from each other be used to generate a different start position value for each UE as described above. It is preferable that as many different values (or numbers) as possible be generated for UEs. Thus, each generated value will be referred to as an "identification dependent randomization number".

FIG. 4 illustrates the principle of a generator that generates identification dependent randomization numbers according to an embodiment of the present invention.

Specifically, a generator 401 receives an input value x and generates an output value $Z_j$ or an output sequence Z according to a generation parameter set $\{K_0, K_0, \ldots K_L\}$ of the generator 401. Although the number of parameters used in the generator is L+1 in the example of FIG. 4, the number and type of the used parameters may vary and will be described in more detail in each embodiment of the present invention described below.

The value generated by the generator 401 may be a binary sequence or may be an integer value into which all or part of the binary sequence is converted.

FIGS. 5 and 6 illustrate an example wherein a part of a binary sequence generated by the generator is selected as an initial value according to an embodiment of the present invention.

That is, as shown in FIG. 5, an M-length binary value for use as an identification dependent randomization number can be selected from a P-length binary sequence generated by the generator 401 described above with reference to FIG. 4. According to this embodiment, a number of identification dependent randomization numbers can be generated after a binary sequence is generated from a specific initial value. That is, as shown in FIG. 6, partial binary sequences that do not overlap can be selected from the binary sequence generated by the generator 401 and a number of identification dependent randomization numbers can then be generated from the selected binary sequences. Although X identification dependent randomization numbers are generated in the example of FIG. 6, the present invention is not necessarily limited to this example.

When the M-length binary sequence selected for calculating an identification dependent randomization number is represented by $\{\hat{y}_0, \hat{y}_1, \hat{y}_2, \ldots, \hat{y}_{M-1}\}$, this can be used to convert the identification dependent randomization number (i.e., the start position information) into an integer value $Z_K$.

MATHEMATICAL EXPRESSION 1

$$Z_k = \left(\sum_{i=0}^{M-1} 2^i \cdot \hat{y}_i\right) \bmod C \qquad Z_k = \left(\sum_{i=0}^{M-1} 2^{M-1-i} \cdot \hat{y}_i\right) \bmod C$$

$$y_k = \sum_{i=0}^{M-1} 2^i \cdot \hat{y} \qquad \text{OR} \qquad y_k = \sum_{i=0}^{M-1} 2^{M-1-i} \cdot \hat{y}_i$$

Here, it is assumed that a subscript "k" represents a subframe index and "C" is defined as the number of candidate positions that can be used as start positions. That is, Mathematical Expression 1 represents that a specific-length binary sequence selected from a binary sequence generated by the generator is converted into an integer value and the integer value is modded with the number of all possible initial positions "C" to generate a start position value.

Specifically, in an embodiment of the present invention, the value "C" for a PDCCH to be currently received can be set to be equal to a value obtained by dividing the total number of physical CCEs by a CCE aggregation level (for example, 1, 2, 4, or 8) which is the number of CCE aggregations that can be used to transmit one PDCCH. If the total number of physical CCEs that can be used for PDCCH transmission is indivisible by the number of CCEs belonging to one PDCCH, the value "C" can be quantized to the number of possible candidate positions based on the above principle. Specifically, this embodiment suggests that the value "C" be obtained using the following equation.

$$C=\mathrm{floor}(N_{CCE}/L_{CCE}), \qquad \text{MATHEMATICAL EXPRESSION 2}$$

where "floor(x)" represents a function to quantize "x" to a largest integer that is equal to or less than "x", $N_{CCE}$ represents the total number of CCEs in a specific subframe, and $L_{CCE}$ is the number of CCEs that are used to transmit one PDCCH.

On the other hand, the generator **401** illustrated in FIG. **4** generates values having a period P. Accordingly, in an embodiment of the present invention, it is taken into consideration that P identification dependent randomization numbers are generated through a value generated through one initial input value. That is, identification dependent randomization numbers may be generated by performing the binary sequence selection and integer conversion described above on a binary sequence generated through one initialization. Alternatively, a total of P identification dependent randomization numbers such as $\{Z_0, Z_1, Z_2, \ldots, Z_{P-1}\}$ may be generated directly from an input initial value.

Communication systems generally operate at preset timings and at intervals of a preset period.

FIG. 7 illustrates a frame structure in the 3GPP LTE system for explaining an example in which a communication system operates at regular intervals.

Specifically, as shown in FIG. 7, the communication system operates at intervals of a period of "10 ms". Here, the period "10 ms" can be referred to as a radio frame. In this system, one radio frame includes 10 subframes, each having a length of "1 ms". Each subframe may have a structure including 0.5 ms slots.

In the example shown in FIG. 7, when randomization effects are achieved using identification dependent randomization numbers, the generated values may also be handled at intervals of 10 ms since the system illustrated in FIG. 7 operates at intervals of 10 ms. That is, a system in which an identification dependent randomization number is required for each subframe may be set to generate a sequence including 10 numbers so that the same sequence is used every period of 10 ms. Alternatively, the system may operate such that a value is generated 10 times every subframe in a radio frame and values are generated in the same manner in a next radio frame so that the same identification dependent randomization number is actually generated at intervals of 10 ms.

Reference will now be made to a method in which a start position for use in PDCCH search is generated directly from an initial input value based on an identification number. In the following, a first embodiment is described as a preferred embodiment of the present invention and second to fourth embodiments are described as other embodiments that can be implemented according to a similar principle.

## First Embodiment

This embodiment suggests that a value obtained by performing a first modulo operation of an input value of "x" with a predetermined constant value of "D" and then performing a second modulo operation of the resulting value with a variable value of "C" corresponding to the number of candidate start positions that can be used as start positions is used as a search space start position for control information search.

Specifically, this embodiment suggests that a start position be determined in the following manner.

$$Z_k=[(A\cdot y_k+B)\bmod D]\bmod C$$

$$y_0=x, y_k=(A\cdot y_{k-1}+B)\bmod D$$

$$k=0, 1, \ldots, P-1 \qquad \text{MATHEMATICAL EXPRESSION 3}$$

More specifically, this embodiment suggests that an initial value "x" be input and then be multiplied by "A" and the sum of the initial value "x" multiplied by "A" and a constant "D" be modded with a variable "C" to generate a final integer as a start position value of a search space. The finally generated value $Z_k$ in Mathematical Expression 3 indicates a start position of a PDCCH search space in a subframe corresponding to an index "k".

The following two methods can be used to calculate a search space start position of a different subframe from the subframe corresponding to the index "k".

In the first method, for each subframe, a different initial value is input to generate a start position value. That is, a different value such as $x_0, x_1, \ldots x_k, \ldots$ is sequentially input as an initial value for each subframe having an index of k to calculate a start position $Z_k$ of a search space of the subframe. In the second method, an intermediate value generated by inputting an initial value is used as an initial value for the next subframe to generate a start position value. That is, a value of $y_{k-1}$ for a subframe having an index of k−1 is used as an input value for a subframe having an index of k.

The above Mathematical Expression 3 according to this embodiment uses the second method. Specifically, as shown in Mathematical Expression 3, a value obtained by multiplying an intermediate value $y_{k-1}$ by a predetermined constant "A", adding the intermediate value $y_{k-1}$ multiplied by "A" to a constant "B", and then modding the resulting value with a constant "D" is used as an initial value $y_k$.

The value corresponding to the number of candidate start positions "C" as defined in the above Mathematical Expression 2 can also be used in this embodiment.

In this embodiment, the purpose of performing a modulo operation with the value "C" defined as in Mathematical Expression 2 is to obtain an output value that is one of the candidate start positions. The following is the reason for performing another modulo operation with "D" before the modulo operation with "C" to obtain a value within a desired range.

Even when values of "Ax+B" are different in Mathematical Expression 3, there is high possibility that corresponding final values obtained by performing a modulo operation of the values "Ax+B" with "C" are likely to be equal if the value "C" is small. The possibility that different values of "Ax+B" cause collision such that they produce the same final value through the modulo operation with the small value "C" can be reduced by performing another modulo operation with the predeter-

mined constant "D". Here, it is preferable that the predetermined constant "D" be set to be higher than the value "C" to reduce the possibility that different values of "Ax+B" cause collision as described above.

In this embodiment, it is assumed that the finally obtained search space start position $Z_k$ in the subframe corresponding to the index "k" indicates a corresponding one of the indices assigned to CCE aggregations corresponding to the CCE aggregation level. That is, when the CCE aggregation level is "2", indices for CCE aggregations are assigned on a 2-CCE basis. Accordingly, the value $Z_k$ obtained according to this embodiment indicates a corresponding one of the CCE aggregation indices assigned as described above.

## Second Embodiment

Unlike the first embodiment, the finally obtained search space start position $Z_k$ in the subframe corresponding to the index "k" may indicate a corresponding CCE position based on an index assigned to each CCE rather than an index assigned to each CCE aggregation. That is, when the CCE aggregation level is "2", a CCE aggregation index may be assigned on a CCE basis rather than on a 2-CCE basis. Accordingly, this embodiment suggests that a vâlue calculated through the following equation be used as a start position of a PDCCH search space under the same condition as in the first embodiment.

$$Z_k = L_{CCE} \cdot [(A \cdot y_k + B) \bmod D] \bmod C$$

$$y_0 = x, y_k = (A \cdot y_{k-1} + B) \bmod D$$

$$k = 0, 1, \ldots, P-1 \qquad \text{MATHEMATICAL EXPRESSION 4}$$

When Mathematical Expression 4 is compared with Mathematical Expression 3 according to the first embodiment, it can be seen that a final value $Z_k$ according to Mathematical Expression 4 is obtained by multiplying the final value $Z_k$ generated according to Mathematical Expression 3 by $L_{CCE}$. That is, the value calculated according to Mathematical Expression 3 is multiplied by the number of CCEs $L_{CCE}$ included in one CCE aggregation according to the CCE aggregation level to generate a value that can be used as a start position of a search space that is also appropriate for a system in which indices are assigned on a CCE basis.

## Third Embodiment

In the above Mathematical Expressions 3 and 4, it is assumed that k starts from "0". However, the index "k" may also be defined to start from "−1". In this case, Mathematical Expressions 3 and 4 can be expressed as follows.

$$Z_k = (Y_k \bmod \lfloor N_{CCE,k}/L \rfloor)$$

$$Y_k = (A \cdot Y_{k-1}) \bmod D \qquad \text{MATHEMATICAL EXPRESSION 5}$$

$$Z_k = L \cdot (Y_k \bmod \lfloor N_{CCE,k}/L \rfloor)$$

$$Y_k = (A \cdot Y_{k-1}) \bmod D \qquad \text{MATHEMATICAL EXPRESSION 6}$$

In Mathematical Expressions 5 and 6, it is assumed that $Y_{-1} = n_{RNTI} \neq 0$ and $n_{RNTI}$ corresponds to a UE ID.

Specifically, Mathematical Expression 5 is equivalent to Mathematical Expression 3 with k starting from −1 and Mathematical Expression 6 is equivalent to Mathematical Expression 4 with k starting from −1.



## Fourth Embodiment

This embodiment suggests a second method for calculating a start position of a PDCCH search space in which the following equation is used unlike those used in the first to third embodiments.

$$Z_k = ((A \cdot x_k + B \cdot x_k^2) \bmod D) \bmod C \qquad \text{MATHEMATICAL EXPRESSION 7}$$

That is, this embodiment suggests that a start position value be generated using a quadratic generation equation as shown in Mathematical Expression 7 as an input value. Here, the input value may be used in both the method in which a new value is input for each generation of a subframe value and the method in which a value generated in a kth generation is used as an input value for a k+1th generation.

On the other hand, a preferred embodiment of the present invention suggests that a number, which is 1 greater than the largest number that the initial value may have, (i.e., a value indicating the range of numbers that the initial value may have) be used as the value "D" in Mathematical Expression 7.

In the above embodiments, it is assumed that UE identification information is used as the initial input value. However, another aspect of the present invention suggests that the initial input value be used in various forms to enable efficient PDCCH transmission and detection.

The basic purpose of each embodiment of the present invention is to generate a different value for any specific identification number, which will also be referred to as an "ID" for short, and thus it is preferable to select an initial value which maximizes randomization effects according to the ID.

Since the purpose of each embodiment of the present invention is to impart randomization effects of PDCCH decoding regions between UEs and a base station and it is not necessary to take into consideration randomization effects between base stations, ID values for identifying UEs such as UE identification numbers (for example, a C-RTNI or a temporary-RNTI) can be selected as initial values. Specifically, all of the following information items or combinations thereof can be used to create initial values.

1. UE ID
2. CCE aggregation Level ($L_{CCE}$)
3. Subframe Number (or Slot Number)

According to the present invention, when a sequence is generated as an ID dependent random number synchronously with the timings of radio frames, both the method in which a start position value is generated using a different initial value every subframe, and the method in which a start position value is generated synchronously with the timings of radio frames and a new ID dependent random number is then generated using the generated start position value or the intermediate value, may be employed as described above.

In the method in which an initial value is input every subframe to generate an ID dependent random number every subframe, the initial value must be changed every subframe and a different value must be generated for each UE and therefore an initial value may be created using a UE ID and a subframe number (or a corresponding slot number). It is preferable that the initial value be created such that a number indicating the UE ID and a number indicating the subframe not overlap when the initial value is expressed in binary form.

FIGS. 8 and 9 illustrate a method for creating an initial value used to generate a start position of a PDCCH search space using a UE ID and a subframe number according to an embodiment of the present invention.

Specifically, as shown in FIG. 8, when the initial value is expressed in binary form, the initial value can be created such

that a 16-bit UE ID is placed at less significant bit positions including a Least Significant Bit (LSB) position of the binary value and a 4-bit subframe number is placed at more significant bit positions including a Most Significant Bit (MSB) position. The initial value created in this manner can be expressed as follows.

$$\{\text{UE-ID}\}\times 2^{0}+\{\text{subframe\#}\}\times 2^{16} \qquad \text{MATHEMATICAL EXPRESSION 8}$$

In addition, as shown in FIG. 9, when the initial value is expressed in binary form, the initial value can be created such that a UE ID is placed at more significant bit positions including a Most Significant Bit (MSB) position of the binary value and a subframe number is placed at less significant bit positions including a Least Significant Bit (LSB) position. In this case, the initial value can be expressed as follows.

$$(\text{UE-ID})\times 2^{4}+\{\text{subframe\#}\}\times 2^{0} \qquad \text{MATHEMATICAL EXPRESSION 9}$$

It is preferable that, when a PDCCH decoding region is randomized, randomization effects of each CCE aggregation level be different since the same physical CCE may be used even when different CCE aggregation levels are employed.

FIG. 10 illustrates an example wherein one of two UEs having different CCE aggregation levels fails to receive a PDCCH destined for the UE due to a PDCCH destined for the other UE.

A problem may occur if the CCE region for PDCCH decoding is the same for all UEs even though their CCE aggregation levels are different. For example, if a PDCCH decoding region corresponding to 8 aggregated CCEs for transmitting a PDCCH to a UE1 must also be used for a UE 2 when the PDCCH is transmitted to the UE 1 using the CCE aggregation of 8 CCEs, a PDCCH may not be able to be transmitted to the UE 2 since a PDCCH decoding region for transmission to the UE2 is entirely covered by the PDCCH that uses the 8 aggregated CCEs.

To overcome this problem, an embodiment of the present invention suggests that a different identification dependent randomization number be generated for each CCE aggregation level. Specifically, the embodiment of the present invention suggests that information of each CCE aggregation level be incorporated into an initial value used to calculate a start position of a PDCCH search space. That is, a UE ID, a subframe number, and a CCE aggregation level may be used to create the initial value.

FIGS. 11 and 12 illustrate examples where a UE ID, a subframe number, and a CCE aggregation level are used to create an initial value according to an embodiment of the present invention.

Specifically, FIG. 11 illustrates an example wherein the initial value includes a subframe number, a CCE aggregation level, and a UE ID at bit positions sequentially from the MSB to the LSB positions and FIG. 12 illustrates an example wherein the initial value includes a UE ID, a CCE aggregation level, and a subframe number at bit positions sequentially from the MSB to the LSB positions. These information items may be arranged in any other order, provided that the initial value includes all the information items.

Alternatively, when the initial value generation methods of the first to fifth embodiments described above are used, an initial value including no subframe number may be input to generate sequences synchronously with the timings of radio frames and sequence values generated in each subframe may then be used one by one. In this case, the initial value can be created using a combination of the UE ID and the CCE aggregation level information since there is no need to incorporate the subframe information into the initial value.

FIGS. 13 and 14 illustrate examples where an initial value used to calculate a start position of a PDCCH search space is created using a UE ID and a CCE aggregation level according to an embodiment of the present invention.

Although the initial value includes a CCE aggregation level and a UE ID at bit positions sequentially from the MSB to the LSB in the example of FIG. 13 and the initial value includes a CCE aggregation level and a UE ID at bit positions in the reverse order in the example of FIG. 14, the CCE aggregation level and the UE ID may be arranged in any order.

On the other hand, another embodiment of the present invention suggests that each of the constant values A, B, and D used in the first to fifth embodiments vary depending on the CCE aggregation level. Although the value C is represented by a function of the CCE aggregation level and thus varies according to circumstances, the values A, B, and D are constants preset at transmitting and receiving sides. However, in order to generate a different identification dependent randomization number pattern for each CCE aggregation level, the values A, B, and D may each be set to be different for each CCE aggregation level.

In a special embodiment, constant values, which are fixed regardless of the CCE aggregation level, may be used as the values A and D used in the first to fourth embodiments while only the value B is defined to be different for each CCE aggregation level. This allows a finally obtained sequence to be different for each CCE aggregation level without significantly changing the characteristics of the generated sequence.

Another possible method is to use only the UE ID as an initial value while especially using fixed, constant values as the values A, B, and D in the first to fifth embodiments since the value C inherently varies according to the CCE aggregation level. It is not necessary to define values A, B, and D that vary according to the CCE aggregation level in the above embodiments since a value randomized to some extent is generated through a modulo operation with the value D and the finally obtained identification dependent random number may vary through the modulo operation with the value C that varies according to the CCE aggregation level.

Reference will now be made in detail to parameter values of the generation equations for obtaining a start position of a PDCCH search space according to the first to fifth embodiments described above.

Using a computer, the present inventor found some values of the parameters A, B, and D of the generator which are good for each method. The good values are defined as follows and the present invention suggests best parameter values for each search criterion described below.

A start position of a PDCCH decoding region for decoding for each CCE aggregation level is obtained based on an identification dependent randomization number. The PDCCH decoding region should be synchronized between the base station and UEs and the period and timing of generation of an identification dependent randomization number should also be synchronized between all UEs that communicate with the base station. Thus, overlapping of PDCCH decoding regions can be minimized if identification dependent randomization numbers that UEs having different UE IDs use every subframe are different. This indicates that, even though some identification dependent randomization numbers are equal among identification dependent randomization numbers generated with different UE IDs, randomization effects can be achieved if the identification dependent randomization numbers are different only in a subframe in which a specific value is used.

In an embodiment of the present invention, a concept of the "number of hits" is defined as a criterion for determining

performance according to each parameter value. Each of the UEs having different UE IDs generates identification dependent randomization numbers synchronously with radio frames and compares identification dependent randomization numbers used in subframes to determine the number of subframes which has used the same value and records the determined number of subframes as the "number of hits". Therefore, a distribution of the numbers of hits with all other possible UE IDs is measured for every UE ID that can be allocated and the distribution of the numbers of hits probabilistically determined when a specific generation method is used is set as one criterion for determining performance.

FIG. **15** illustrates the concept of the number of hits used for determining performance when parameter values are calculated according to an embodiment of the present invention.

That is, the embodiment of the present invention suggests that, since 10 subframes are included in a radio frame in the 3GPP LTE as shown in FIG. **15**, the number of possible hits be determined for subframe indices of 0, 1, . . . , 10 and the determined number of hits be used as a probability that UEs having two different UE IDs use the same PDCCH decoding region (i.e., as a criterion for determining performance).

On the other hand, an embodiment of the present invention suggests that a distribution map of an identification dependent randomization number(s) that can be generated from all input initial values that can be generated according to the generation method with specific parameters A, B, and D be taken into consideration as a second criterion for determining performance. Identification dependent randomization numbers generated using all generation methods suggested in the present invention are between 0 to C−1. Therefore, the embodiment of the present invention suggests that a distribution of integer values between 0 to C−1 generated for all initial values that can be input be measured and whether or not all generated values are as uniform as possible then be determined and the uniformity of the generated values then be used as a criterion for determining performance.

In this embodiment, the following performance indicators are selected from performance results. When specific parameters are used in each generation method, the following indicators are calculated and compared. Here, the average of values measured when the value C varies in a range from 96 to 3 is determined for each of the indicators.

1. Maximum number of hits
2. Average number of hits
3. Whether or not ID dependent randomization numbers have been generated uniformly in a range of 0 to C−1
4. Variance of probabilities that values between 0 to C−1 will be generated for determining whether or not ID dependent randomization numbers have been generated uniformly in a range of 0 to C−1

First, parameter values used in the method for generating a start position of a PDCCH search space according to the first embodiment are described below with reference to the above description.

Various values can be used as constant values A, B, and D that are predetermined and used at the transmitting and receiving sides in the generation method according to the first embodiment. Thus, it is difficult to measure performance of all possible values of A, B, and D using a computer. Therefore, values of A, B, and D that generally exhibited high performance were first confirmed using a computer and respective performance of specific combinations of A, B, and D was compared based on the confirmed values.

First, results of performance measurement using a computer showed that the value D exhibited highest performance when similar to the maximum value that can be expressed by the initial value x with A and B fixed to specific values. Results shown in Table 2 are part of performance measurement results indicating the probability that sequences generated for different UE IDs using an initial value created using only the UE IDs according to the first embodiment become equal in each subframe. The UE ID consists of 16 bits that correspond to 65536 ($-2^{16}$) values.

TABLE 2

| Parameters | | | | Probability per Number of Hits | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 4093 | 7 | 96 | 65536 | 96.931% | 0.270% | 0.613% | 0.811% | 0.705% | 0.431% | 0.183% | 0.048% | 0.007% | 0.000% | 0.000% |
| 4093 | 7 | 86 | 65536 | 89.560% | 9.404% | 0.926% | 0.088% | 0.021% | 0.002% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 76 | 65536 | 89.585% | 8.162% | 1.876% | 0.297% | 0.062% | 0.017% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 66 | 65536 | 86.717% | 11.644% | 1.464% | 0.142% | 0.029% | 0.005% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 56 | 65536 | 90.213% | 4.439% | 3.376% | 1.422% | 0.404% | 0.110% | 0.031% | 0.005% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 46 | 65536 | 81.970% | 14.810% | 2.822% | 0.333% | 0.053% | 0.012% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 36 | 65536 | 82.624% | 9.787% | 5.402% | 1.699% | 0.384% | 0.086% | 0.018% | 0.001% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 26 | 65536 | 72.397% | 18.821% | 7.045% | 1.460% | 0.234% | 0.039% | 0.004% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 16 | 65536 | 93.751% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 6.249% |
| 4093 | 7 | 6 | 65536 | 50.867% | 4.337% | 9.753% | 13.06% | 11.379% | 6.833% | 2.844% | 0.812% | 0.152% | 0.015% | 0.001% |
| 4093 | 7 | 96 | 65537 | 90.078% | 9.459% | 0.444% | 0.018% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 86 | 65537 | 88.977% | 10.457% | 0.542% | 0.024% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 76 | 65537 | 87.601% | 11.686% | 0.681% | 0.031% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 66 | 65537 | 85.830% | 13.248% | 0.879% | 0.043% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 56 | 65537 | 83.471% | 15.281% | 1.182% | 0.065% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 46 | 65537 | 80.216% | 17.964% | 1.705% | 0.112% | 0.004% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 36 | 65537 | 75.410% | 21.668% | 2.684% | 0.225% | 0.013% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 26 | 65537 | 67.471% | 27.239% | 4.709% | 0.536% | 0.045% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 16 | 65537 | 52.355% | 35.182% | 10.360% | 1.846% | 0.241% | 0.016% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 6 | 65537 | 16.152% | 32.305% | 29.049% | 15.530% | 5.421% | 1.303% | 0.216% | 0.022% | 0.001% | 0.000% | 0.000% |
| 4093 | 7 | 96 | 131071 | 90.052% | 9.500% | 0.443% | 0.005% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 86 | 131071 | 88.956% | 10.484% | 0.552% | 0.008% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 76 | 131071 | 87.603% | 11.667% | 0.714% | 0.015% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 66 | 131071 | 85.869% | 13.150% | 0.959% | 0.022% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 56 | 131071 | 83.506% | 15.186% | 1.268% | 0.039% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 46 | 131071 | 80.272% | 17.820% | 1.822% | 0.082% | 0.003% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 36 | 131071 | 75.448% | 21.532% | 2.839% | 0.173% | 0.008% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 26 | 131071 | 67.563% | 26.983% | 4.938% | 0.478% | 0.035% | 0.002% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 16 | 131071 | 52.421% | 34.996% | 10.518% | 1.826% | 0.218% | 0.020% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% |

TABLE 2-continued

| Parameters | | | | Probability per Number of Hits | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 4093 | 7 | 6 | 131071 | 16.152% | 32.303% | 29.064% | 15.505% | 5.436% | 1.305% | 0.212% | 0.022% | 0.001% | 0.000% | 0.000% |
| 4093 | 7 | 96 | 1048576 | 96.933% | 0.273% | 0.608% | 0.810% | 0.705% | 0.423% | 0.181% | 0.056% | 0.011% | 0.001% | 0.000% |
| 4093 | 7 | 86 | 1048576 | 89.526% | 9.415% | 0.980% | 0.075% | 0.004% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 76 | 1048576 | 89.539% | 8.158% | 1.963% | 0.305% | 0.032% | 0.003% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 66 | 1048576 | 86.711% | 11.603% | 1.538% | 0.135% | 0.011% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 56 | 1048576 | 90.226% | 4.407% | 3.331% | 1.485% | 0.448% | 0.088% | 0.013% | 0.001% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 46 | 1048576 | 81.991% | 14.739% | 2.868% | 0.363% | 0.037% | 0.002% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 36 | 1048576 | 82.819% | 9.543% | 5.299% | 1.831% | 0.420% | 0.076% | 0.011% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 26 | 1048576 | 72.450% | 18.720% | 7.031% | 1.552% | 0.226% | 0.020% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 16 | 1048576 | 93.751% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 6.249% |
| 4093 | 7 | 6 | 1048576 | 50.873% | 4.339% | 9.758% | 12.995% | 11.371% | 6.828% | 2.852% | 0.815% | 0.152% | 0.016% | 0.001% |
| 4093 | 7 | 96 | 1048593 | 90.946% | 7.811% | 1.145% | 0.089% | 0.007% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 86 | 1048593 | 89.008% | 10.392% | 0.580% | 0.020% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 76 | 1048593 | 87.581% | 11.711% | 0.690% | 0.017% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 66 | 1048593 | 87.595% | 9.980% | 2.141% | 0.265% | 0.019% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 56 | 1048593 | 89.444% | 5.445% | 3.401% | 1.315% | 0.333% | 0.055% | 0.006% | 0.001% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 46 | 1048593 | 95.658% | 0.043% | 0.191% | 0.509% | 0.891% | 1.070% | 0.892% | 0.510% | 0.190% | 0.041% | 0.004% |
| 4093 | 7 | 36 | 1048593 | 80.612% | 12.724% | 5.202% | 1.240% | 0.198% | 0.021% | 0.002% | 0.001% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 26 | 1048593 | 92.317% | 0.074% | 0.337% | 0.903% | 1.578% | 1.892% | 1.578% | 0.902% | 0.338% | 0.075% | 0.007% |
| 4093 | 7 | 16 | 1048593 | 52.396% | 35.073% | 10.456% | 1.826% | 0.225% | 0.022% | 0.002% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 6 | 1048593 | 66.700% | 0.325% | 1.465% | 3.905% | 6.836% | 8.206% | 6.836% | 3.904% | 1.465% | 0.325% | 0.032% |
| 4093 | 7 | 96 | 2097143 | 90.048% | 9.514% | 0.425% | 0.012% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 86 | 2097143 | 88.997% | 10.412% | 0.572% | 0.019% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 76 | 2097143 | 87.614% | 11.655% | 0.704% | 0.027% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 66 | 2097143 | 85.845% | 13.210% | 0.911% | 0.034% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 56 | 2097143 | 83.487% | 15.250% | 1.200% | 0.063% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 46 | 2097143 | 80.294% | 17.816% | 1.765% | 0.120% | 0.005% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 36 | 2097143 | 75.434% | 21.612% | 2.724% | 0.217% | 0.013% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 26 | 2097143 | 67.573% | 26.986% | 4.897% | 0.512% | 0.031% | 0.001% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 16 | 2097143 | 52.462% | 34.907% | 10.552% | 1.859% | 0.206% | 0.014% | 0.000% | 0.000% | 0.000% | 0.000% | 0.000% |
| 4093 | 7 | 6 | 2097143 | 16.176% | 32.240% | 29.086% | 15.553% | 5.420% | 1.280% | 0.216% | 0.027% | 0.002% | 0.000% | 0.000% |

As shown in Table 2, the probability that collision occurs (i.e., UE IDs become equal) in all of the 10 subframes is 6.429% when the value D is equal to an initial value of $2^{16}$ and the value C is 16. However, this phenomenon disappears when the value D is greater than $2^{16}$. It can be seen from Table 2 that the phenomenon disappears when the value D is 65537 or 131071 which are greater than $2^{16}$. However, such poor performance results occur when a value much greater than $2^{16}$ is selected as the value D. That is, such results occur when the value D is 1048576 or 1048593. Although performance is increased when the value D is 2097143, the performance is, on average, lower than that when a value which is close to $2^{16}$ and greater than $2^{16}$ is used as the value D.

Based on these facts, an embodiment of the present invention suggests that a prime number greater than $2^N$ and less than $2^{N+1}$ be used as the parameter value D when the initial value is expressed by N bits. Preferably, the smallest prime number greater than $2^N$ is used as the parameter value D. Specifically, an embodiment suggests that a value of $2^{16}+1$ be used as the value D when N=16, a value of $2^{18}+3$ be used as the value D when N=18, and a value of $2^{22}+15$ be used as the value D when N=22. The reason why this embodiment suggests that the smallest prime number that satisfies performance requirements be used as the value D is that the simplicity of phenomenon increases, approaching that of normal phenomena, as the value D decreases.

Consequently, an embodiment of the present invention suggests that a value of 65537 be used as the parameter D of the start position generation equation according to the first embodiment of the present invention when it is assumed that the initial value for the generation equation is generated based on a 16-bit UE ID.

On the other hand, to select a parameter value of B, performance was measured using various values of A and various values of B with the value D being fixed to a specific value. Such measurement results showed that the parameter B has no significant influence on the variance of the probabilistic distribution of generation of each value of between 0 and C−1, the average number of collisions, and the maximum number of collisions when the parameters D and A are prime. The following Table 3 shows part of the various performance measurement results.

TABLE 3

| A | B | D | Variance of probability of generation for each number between 0 and c-1 | Average number of Hits | Maximum number of hits |
|---|---|---|---|---|---|
| 32789 | 0 | 1048567 | 8.29439756700E−04 | 1.31635866660E+00 | 6 |
| 32789 | 7 | 1048567 | 8.29439750350E−04 | 1.31635868060E+00 | 6 |
| 32789 | 3821 | 1048567 | 8.29439765480E−04 | 1.31635878580E+00 | 6 |
| 33037 | 0 | 1048567 | 8.29439348280E−04 | 1.31635500230E+00 | 7 |
| 33037 | 7 | 1048567 | 8.29439329360E−04 | 1.31635487980E+00 | 7 |
| 33037 | 3821 | 1048567 | 8.29439315490E−04 | 1.31635479360E+00 | 7 |
| 34421 | 0 | 1048567 | 8.29439612880E−04 | 1.31635698230E+00 | 10 |
| 34421 | 7 | 1048567 | 8.29439589840E−04 | 1.31635668660E+00 | 10 |
| 34421 | 3821 | 1048567 | 8.29439602550E−04 | 1.31635693940E+00 | 10 |

TABLE 3-continued

| A | B | D | Variance of probability of generation for each number between 0 and c-1 | Average number of Hits | Maximum number of hits |
|---|---|---|---|---|---|
| 36061 | 0 | 1048567 | 8.29439625390E-04 | 1.31635759420E+00 | 8 |
| 36061 | 7 | 1048567 | 8.29439596140E-04 | 1.31635773990E+00 | 8 |
| 36061 | 3821 | 1048567 | 8.29439654740E-04 | 1.31635777670E+00 | 8 |
| 41189 | 0 | 1048567 | 8.29441337570E-04 | 1.31637294490E+00 | 6 |
| 41189 | 7 | 1048567 | 8.29441321130E-04 | 1.31637275310E+00 | 6 |
| 41189 | 3821 | 1048567 | 8.29441026210E-04 | 1.31637274940E+00 | 6 |
| 43789 | 0 | 1048567 | 8.29675510000E-04 | 1.31860997820E+00 | 7 |
| 43789 | 7 | 1048567 | 8.29674822710E-04 | 1.31859473170E+00 | 7 |
| 43789 | 3821 | 1048567 | 8.29673565670E-04 | 1.31860202780E+00 | 7 |
| 47653 | 0 | 1048567 | 8.29440200970E-04 | 1.31636344580E+00 | 8 |
| 47653 | 7 | 1048567 | 8.29440320540E-04 | 1.31636344670E+00 | 8 |
| 47653 | 3821 | 1048567 | 8.29440282120E-04 | 1.31636322130E+00 | 8 |

Therefore, an embodiment of the present invention suggests that the parameter values D and A be set to be prime and the parameter value B be set to a very small integer or 0. The complexity of calculation can be reduced when the value B is 0 or approaches 0.

Consequently, a preferred embodiment of the present invention suggests that the parameter value B be set to "0" in the generation equation of the first embodiment.

On the other hand, to select a parameter value A, performance was measured using an available prime number less than the value D while fixing the value B, which is determined to have no significant influence on performance, to a specific value and fixing the value D to a value that exhibited high performance according to the initial value. The following Table 4 shows part of such performance measurement results.

TABLE 4

| A | B | D | Variance of probability of generation for each number between 0 and c-1 | Average number of Hits | Maximum number of hits |
|---|---|---|---|---|---|
| 39827 | 7 | 65537 | 8.29439188640E-04 | 1.31635211090E+00 | 6 |
| 34231 | 7 | 65537 | 8.29439188930E-04 | 1.31635211140E+00 | 6 |
| 46889 | 7 | 65537 | 8.29439189470E-04 | 1.31635211190E+00 | 6 |
| 52289 | 7 | 65537 | 8.29439190000E-04 | 1.31635211190E+00 | 6 |
| 55717 | 7 | 65537 | 8.29439189710E-04 | 1.31635211190E+00 | 6 |
| 53831 | 7 | 65537 | 8.29439189320E-04 | 1.31635211190E+00 | 6 |
| 32993 | 7 | 65537 | 8.29439189850E-04 | 1.31635211230E+00 | 6 |
| 50923 | 7 | 65537 | 8.29439190530E-04 | 1.31635211280E+00 | 6 |
| 56131 | 7 | 65537 | 8.29439190290E-04 | 1.31635211280E+00 | 6 |
| 60889 | 7 | 65537 | 8.29439190530E-04 | 1.31635211280E+00 | 6 |
| 63601 | 7 | 65537 | 8.29439190390E-04 | 1.31635211280E+00 | 6 |
| 53437 | 7 | 65537 | 8.29439190780E-04 | 1.31635211280E+00 | 6 |
| 40151 | 7 | 65537 | 8.29439190530E-04 | 1.31635211280E+00 | 6 |
| 46831 | 7 | 65537 | 8.29439190190E-04 | 1.31635211280E+00 | 6 |
| 36011 | 7 | 65537 | 8.29439190820E-04 | 1.31635211330E+00 | 6 |
| 64747 | 7 | 65537 | 8.29439190630E-04 | 1.31635211330E+00 | 6 |
| 39041 | 7 | 65537 | 8.29439190680E-04 | 1.31635211330E+00 | 6 |
| 47609 | 7 | 65537 | 8.29439190820E-04 | 1.31635211330E+00 | 6 |
| 34501 | 7 | 65537 | 8.29439191160E-04 | 1.31635211330E+00 | 6 |
| 36821 | 7 | 65537 | 8.29439190820E-04 | 1.31635211330E+00 | 6 |
| 42061 | 7 | 65537 | 8.29439191210E-04 | 1.31635211330E+00 | 6 |
| 34703 | 7 | 65537 | 8.29439190820E-04 | 1.31635211330E+00 | 6 |
| 35863 | 7 | 65537 | 8.29439190730E-04 | 1.31635211330E+00 | 6 |
| 47639 | 7 | 65537 | 8.29439190870E-04 | 1.31635211330E+00 | 6 |
| 51767 | 7 | 65537 | 8.29439190820E-04 | 1.31635211330E+00 | 6 |
| 40627 | 7 | 65537 | 8.29439191450E-04 | 1.31635211370E+00 | 6 |
| 40883 | 7 | 65537 | 8.29439191450E-04 | 1.31635211370E+00 | 6 |
| 41011 | 7 | 65537 | 8.29439191160E-04 | 1.31635211370E+00 | 6 |
| 44483 | 7 | 65537 | 8.29439191310E-04 | 1.31635211370E+00 | 6 |
| 45179 | 7 | 65537 | 8.29439191120E-04 | 1.31635211370E+00 | 6 |
| 45523 | 7 | 65537 | 8.29439191210E-04 | 1.31635211370E+00 | 6 |
| 58043 | 7 | 65537 | 8.29439191160E-04 | 1.31635211370E+00 | 6 |
| 59083 | 7 | 65537 | 8.29439191450E-04 | 1.31635211370E+00 | 6 |
| 64499 | 7 | 65537 | 8.29439191410E-04 | 1.31635211370E+00 | 6 |
| 41521 | 7 | 65537 | 8.29439191210E-04 | 1.31635211370E+00 | 6 |
| 42281 | 7 | 65537 | 8.29439191310E-04 | 1.31635211370E+00 | 6 |
| 43577 | 7 | 65537 | 8.29439191210E-04 | 1.31635211370E+00 | 6 |
| 45737 | 7 | 65537 | 8.29439191450E-04 | 1.31635211370E+00 | 6 |
| 49481 | 7 | 65537 | 8.29439191500E-04 | 1.31635211370E+00 | 6 |
| 57041 | 7 | 65537 | 8.29439191450E-04 | 1.31635211370E+00 | 6 |
| 34877 | 7 | 65537 | 8.29439191410E-04 | 1.31635211370E+00 | 6 |
| 41957 | 7 | 65537 | 8.29439191210E-04 | 1.31635211370E+00 | 6 |
| 45389 | 7 | 65537 | 8.29439191410E-04 | 1.31635211370E+00 | 6 |

TABLE 4-continued

| A | B | D | Variance of probability of generation for each number between 0 and c-1 | Average number of Hits | Maximum number of hits |
|---|---|---|---|---|---|
| 61861 | 7 | 65537 | 8.29439191500E−04 | 1.31635211370E+00 | 6 |
| ... | ... | ... | ... | ... | ... |
| 51977 | 7 | 65537 | 8.29439195530E−04 | 1.31635211740E+00 | 9 |
| 61441 | 7 | 65537 | 8.29439193350E−04 | 1.31635211510E+00 | 9 |
| 64513 | 7 | 65537 | 8.29439196010E−04 | 1.31635211790E+00 | 9 |
| 65521 | 7 | 65537 | 8.29439192330E−04 | 1.31635211370E+00 | 9 |
| 34607 | 7 | 65537 | 8.29439192670E−04 | 1.31635211510E+00 | 9 |
| 53239 | 7 | 65537 | 8.29439196260E−04 | 1.31635211840E+00 | 9 |
| 63863 | 7 | 65537 | 8.29439194270E−04 | 1.31635211650E+00 | 9 |

In Table 4, values of "A" exhibiting the smallest numbers of collisions are first arranged and remaining values are arranged in decreasing order of the average number of collisions. That is, the value of A located at an upper portion of Table 4 exhibits high performance in terms of performance indicators. Thus, an embodiment of the present invention suggests that one of the values written above symbols "..." in Table 4 be used as the value A. Particularly, a preferred embodiment of the present invention suggests that a value of 39827 written at the top of Table 4 be used as the value A.

Consequently, a preferred embodiment of the present invention suggests that values of 39827, 0, and 65537 be used respectively as the parameter values A, B, and D of the generation equation according to the first embodiment of the present invention. However, when it is necessary to use other parameter values according to system requirements, values selected from those written in the following table can be used as the parameter values A, B, and D.

TABLE 5

| A | B | D |
|---|---|---|
| 39827, 34231, 46889, 52289 | 0, 1, 3, 5, 7 | $2^{16}+1, 2^{18}+3, 2^{20}+7, 2^{22}+15,$ |

The equations for calculating a start position of a PDCCH search space according to the second to fourth embodiments are substantially identical to that of the first embodiment in terms of their meanings. Accordingly, the present invention suggests that values of 39827, 0, and 65537 also be used respectively as the parameter values A, B, and D in the second to fourth embodiments. In this case, values written in Table 5 can be used as the parameter values A, B, and D when it is necessary to use parameter values other than 39827, 0, and 65537 according to system requirements.

The parameters of the generation equation used in the fifth embodiment of the present invention can also be determined in a manner similar to the method described above. The present inventor also measured various performance criteria for the parameters of the generation equation of the fifth embodiment and suggests that the following combinations of parameters be used.

TABLE 6

| A | B | D |
|---|---|---|
| 7 | 16 | $2^{20}$ |
| 15 | 32 | $2^{20}$ |
| 31 | 64 | $2^{20}$ |

The detailed description of the preferred embodiments of the present invention has been given to enable those skilled in the art to implement and practice the invention. Although the invention has been described with reference to the preferred embodiments, those skilled in the art will appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention described in the appended claims.

Accordingly, the invention should not be limited to the specific embodiments described herein, but should be accorded the broadest scope consistent with the principles and novel features disclosed herein.

The above embodiments can be applied not only to the 3GPP LTE system but also to various other systems that need to transmit a downlink control channel to each UE.

What is claimed is:

**1**. A method for decoding control information by a User Equipment (UE), the method comprising:

receiving a Physical Downlink Control Channel (PDCCH) from a base station at subframe k; and

decoding a set of PDCCH candidates within a search space of the PDCCH at the subframe k, wherein each of the set of PDCCH candidates comprises 'L' control channel elements (CCEs),

wherein the 'L' CCEs corresponding to a specific PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation, wherein 'C' is determined as 'floor(N/L)', wherein 'N' represents a total number of CCEs in the subframe k, and

wherein $Y_k$ is defined by:

$$Y_k=(A*Y_{k-1})\bmod D,$$

wherein A, and D are predetermined constant values.

**2**. The method of claim **1**, wherein A and D are 39827 and 65537, respectively.

**3**. The method of claim **1**, wherein 'L' is one of 1, 2, 4 and 8.

**4**. The method of claim **1**, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by:

$$L*\{(Y_k)\bmod(\mathrm{floor}(N/L))\}.$$

**5**. The method of claim **1**, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are located at positions given by:

$$L*\{(Y_k)\bmod(\mathrm{floor}(N/L))\}+i,\ \text{wherein } i=0,\ldots,L-1.$$

**6**. A user equipment (UE) for decoding control information, the UE comprising:

a receiver for receiving a Physical Downlink Control Channel (PDCCH) from a base station at subframe k; and

a decoder for decoding a set of PDCCH candidates within a search space of the PDCCH at the subframe k, wherein each of the set of PDCCH candidates comprises 'L' control channel elements (CCEs),

wherein the 'L' CCEs corresponding to a specific PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation, wherein 'C' is determined as 'floor(N/L)', wherein 'N' represents a total number of CCEs in the subframe k, and

wherein $Y_k$ is defined by:

$$Y_k=(A*Y_{k-1})\bmod D,$$

wherein A, and D are predetermined constant values.

7. The UE of claim 6, wherein A and D are 39827 and 65537, respectively.

8. The UE of claim 6, wherein 'L' is one of 1, 2, 4 and 8.

9. The UE of claim 6, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by:

$$L*\{(Y_k)\mathrm{mod}(\mathrm{floor}(N/L))\}.$$

10. The UE of claim 6, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are located at positions given by:

$$L*\{(Y_k)\mathrm{mod}(\mathrm{floor}(N/L))\}+i,\ \text{wherein } i=0, \ldots, L-1.$$

11. A method for transmitting control information by a base station, the method comprising:

transmitting a Physical Downlink Control Channel (PDCCH) to a user equipment (UE) at subframe k, wherein the PDCCH comprises a set of PDCCH candidates, wherein each of the set of PDCCH candidates comprises 'L' control channel elements (CCEs) within a search space of the PDCCH at the subframe k,

wherein the 'L' CCEs corresponding to a specific PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation, wherein 'C' is determined as 'floor(N/L)', wherein 'N' represents a total number of CCEs in the subframe k, and

wherein $Y_k$ is defined by:

$$Y_k=(A*Y_{k-1})\bmod D,$$

wherein A, and D are predetermined constant values.

12. The method of claim 11, wherein A and D are 39827 and 65537, respectively.

13. The method of claim 11, wherein 'L' is one of 1, 2, 4 and 8.

14. The method of claim 11, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by:

$$L*\{(Y_k)\mathrm{mod}(\mathrm{floor}(N/L))\}.$$

15. The method of claim 11, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are located at positions given by:

$$L*\{(Y_k)\mathrm{mod}(\mathrm{floor}(N/L))\}+i,\ \text{wherein } i=0, \ldots, L-1.$$

16. A base station for transmitting control information, the base station comprising:

a transmitter for transmitting a Physical Downlink Control Channel (PDCCH) to a user equipment (UE) at subframe k, wherein the PDCCH comprises a set of PDCCH candidates, wherein each of the set of PDCCH candidates comprises 'L' control channel elements (CCEs) within a search space of the PDCCH at the subframe k,

wherein the 'L' CCEs corresponding to a specific PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by using a variable of $Y_k$ for the subframe k and a modulo 'C' operation, wherein 'C' is determined as 'floor(N/L)', wherein 'N' represents a total number of CCEs in the subframe k, and

wherein $Y_k$ is defined by:

$$Y_k=(A*Y_{k-1})\bmod D,$$

wherein A, and D are predetermined constant values.

17. The base station of claim 16, wherein A and D are 39827 and 65537, respectively.

18. The base station of claim 16, wherein 'L' is one of 1, 2, 4 and 8.

19. The base station of claim 16, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are contiguously located from a position given by:

$$L*\{(Y_k)\mathrm{mod}(\mathrm{floor}(N/L))\}.$$

20. The base station of claim 16, wherein the 'L' CCEs corresponding to a first PDCCH candidate among the set of PDCCH candidates of the search space at the subframe k are located at positions given by:

$$L*\{(Y_k)\mathrm{mod}(\mathrm{floor}(N/L))\}+i,\ \text{wherein } i=0, \ldots, L-1.$$

* * * * *

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ISSUE DATE: *February 26, 2013*

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2:19-cv-00066-JRG

US008385284B2

(12) **United States Patent**
**Wengerter et al.**

(10) **Patent No.:** **US 8,385,284 B2**
(45) **Date of Patent:** **Feb. 26, 2013**

(54) **CONTROL CHANNEL SIGNALING USING A COMMON SIGNALING FIELD FOR TRANSPORT FORMAT AND REDUNDANCY VERSION**


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(73) Assignee: **Panasonic Corporation**, Osaka (JP)



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***H04L 1/14*** (2006.01)

(52) **U.S. Cl.** ....................................... **370/329**; 714/750

(58) **Field of Classification Search** .................. 370/328, 370/329; 714/748, 750
See application file for complete search history.


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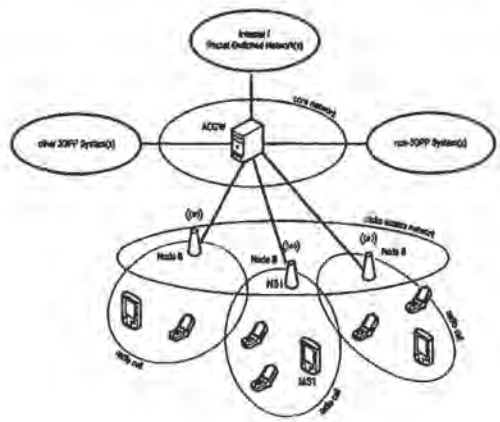
(74) *Attorney, Agent, or Firm* — Seed IP Law Group PLLC

(57) **ABSTRACT**


The invention relates to a method for providing control signalling associated to a protocol data unit conveying user data in a mobile communication system and to the control channel signal itself. Furthermore, the invention also provides a mobile station and a base station and their respective operation in view of the newly defined control channel signals defined herein. In order to reduce the control channel overhead, the invention suggests defining a common field for the transport format and redundancy version in the control channel information format. According to one approach, the common field is used to jointly encode transport format and redundancy version therein. According to another aspect, one shared field is provided on the control channel signal that indicates either a transport format or a redundancy version depending of whether the control channel signal relates to an initial transmission or a retransmission. In another embodiment, further enhancements to a HARQ protocol are suggested for addressing certain error cases.


**35 Claims, 7 Drawing Sheets**



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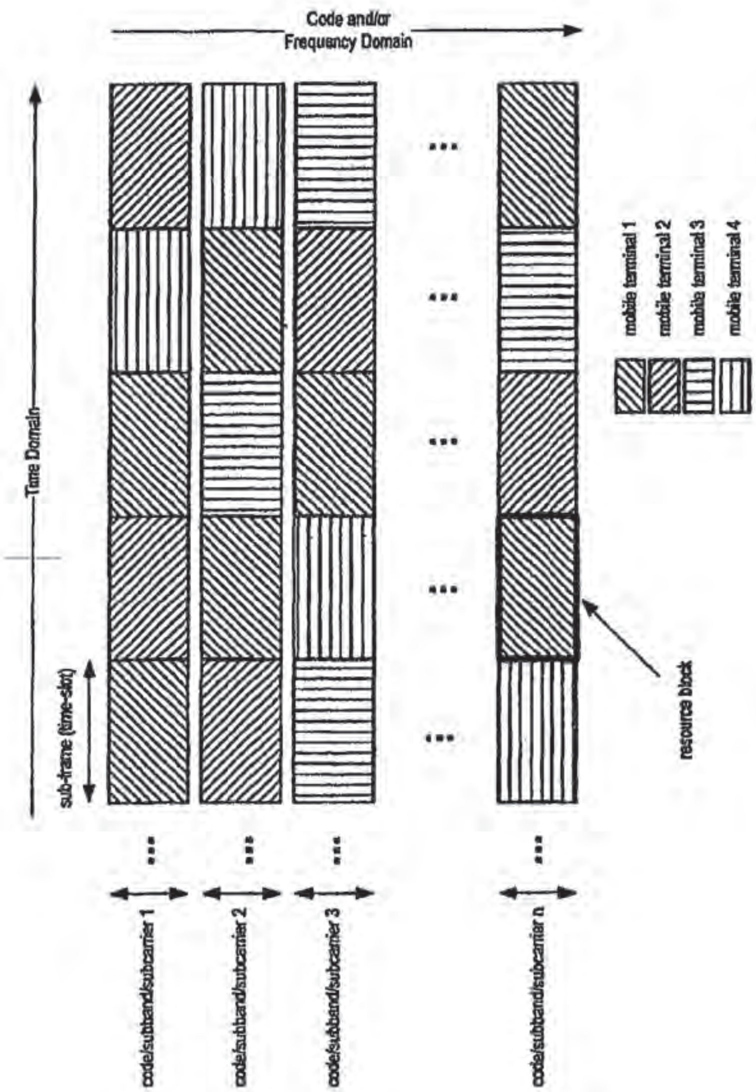



Fig. 1

PRIOR ART

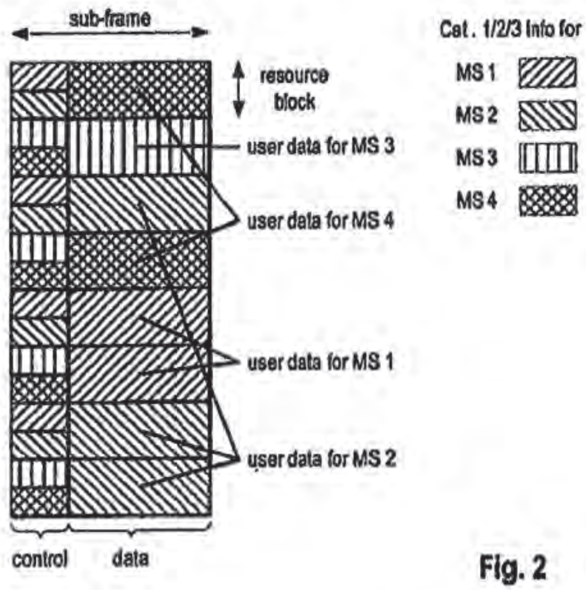



Fig. 2

PRIOR ART

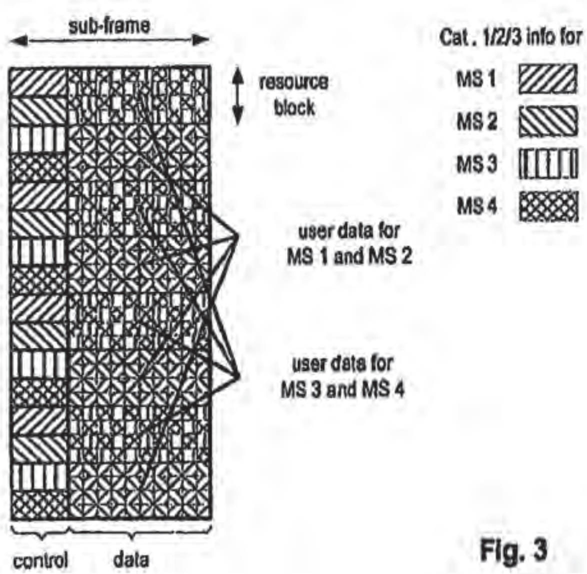



Fig. 3

PRIOR ART

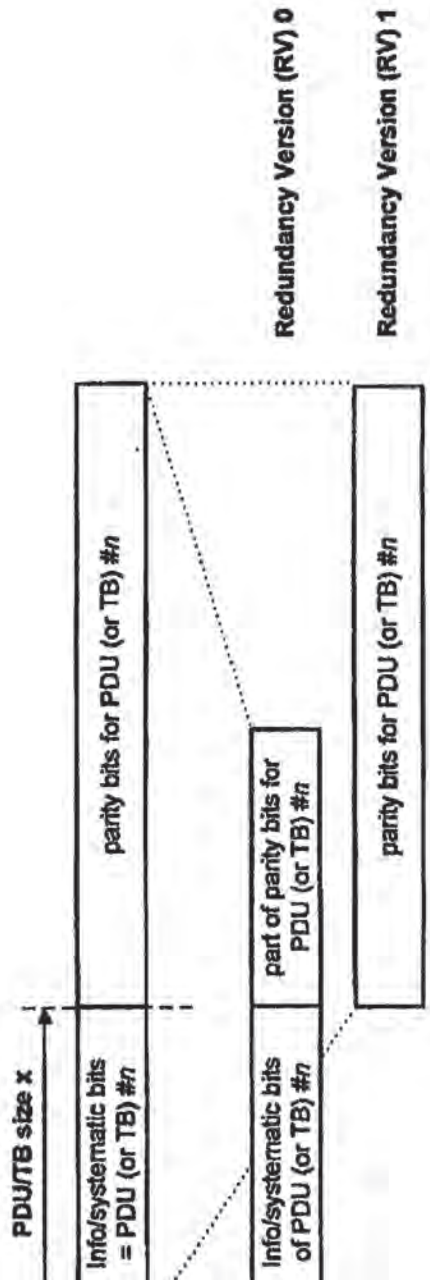



Fig. 4

PRIOR ART

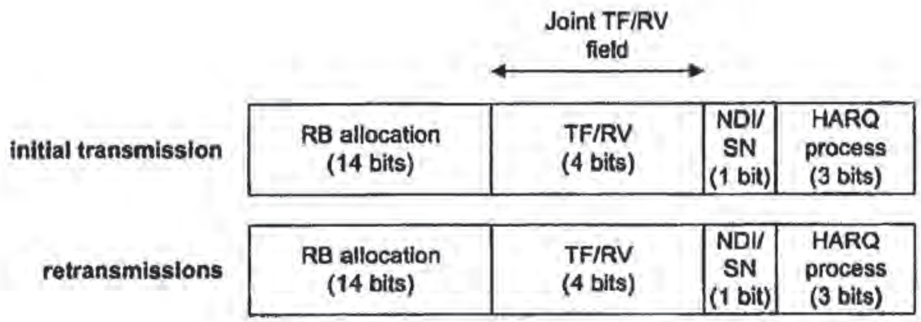



Fig. 5

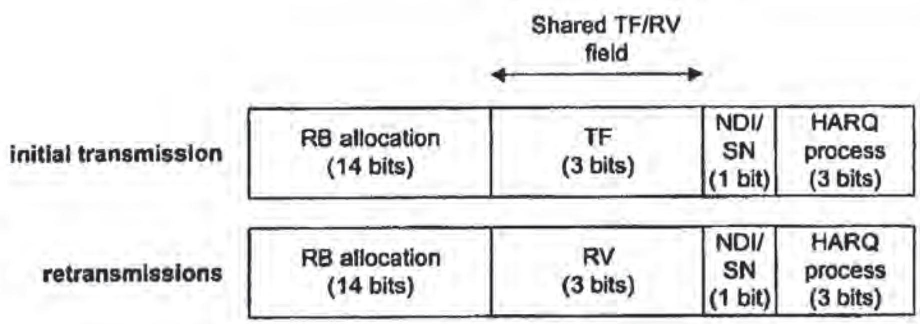



Fig. 6

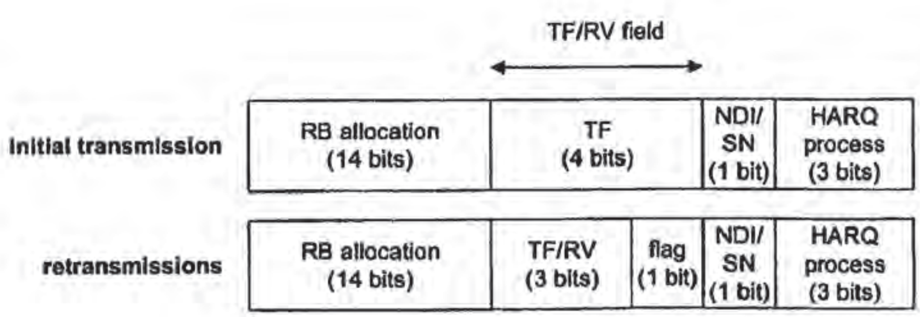



Fig. 7

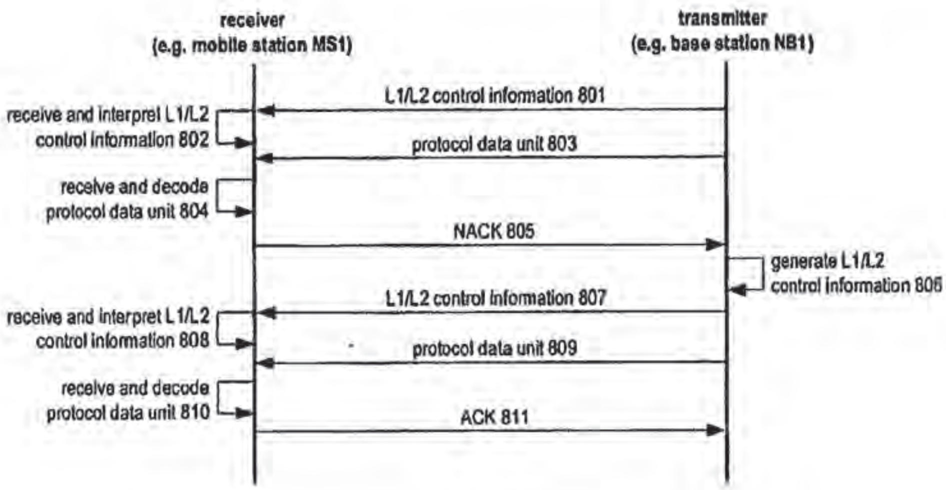

receiver
(e.g. mobile station MS1)
transmitter
(e.g. base station NB1)
L1/L2 control information 801
receive and interpret L1/L2 control information 802
protocol data unit 803
receive and decode protocol data unit 804
NACK 805
generate L1/L2 control information 806
L1/L2 control information 807
receive and interpret L1/L2 control information 808
protocol data unit 809
receive and decode protocol data unit 810
ACK 811

Fig. 8

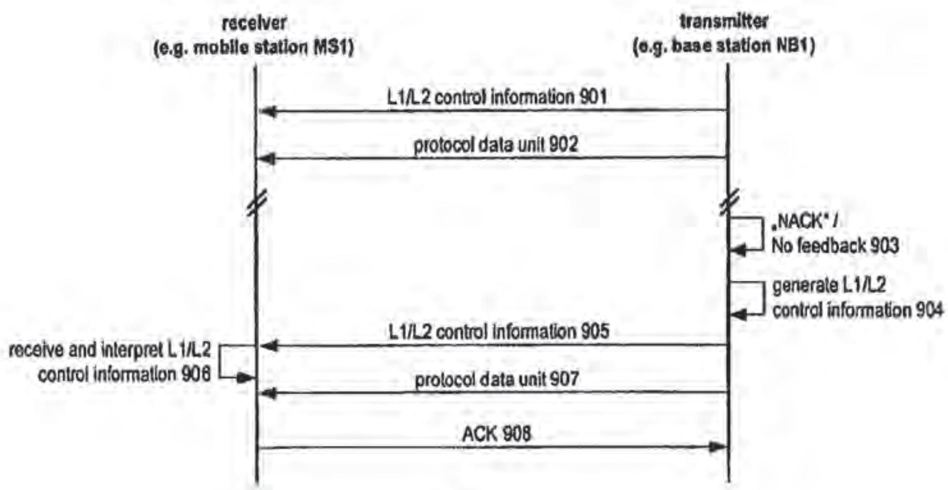
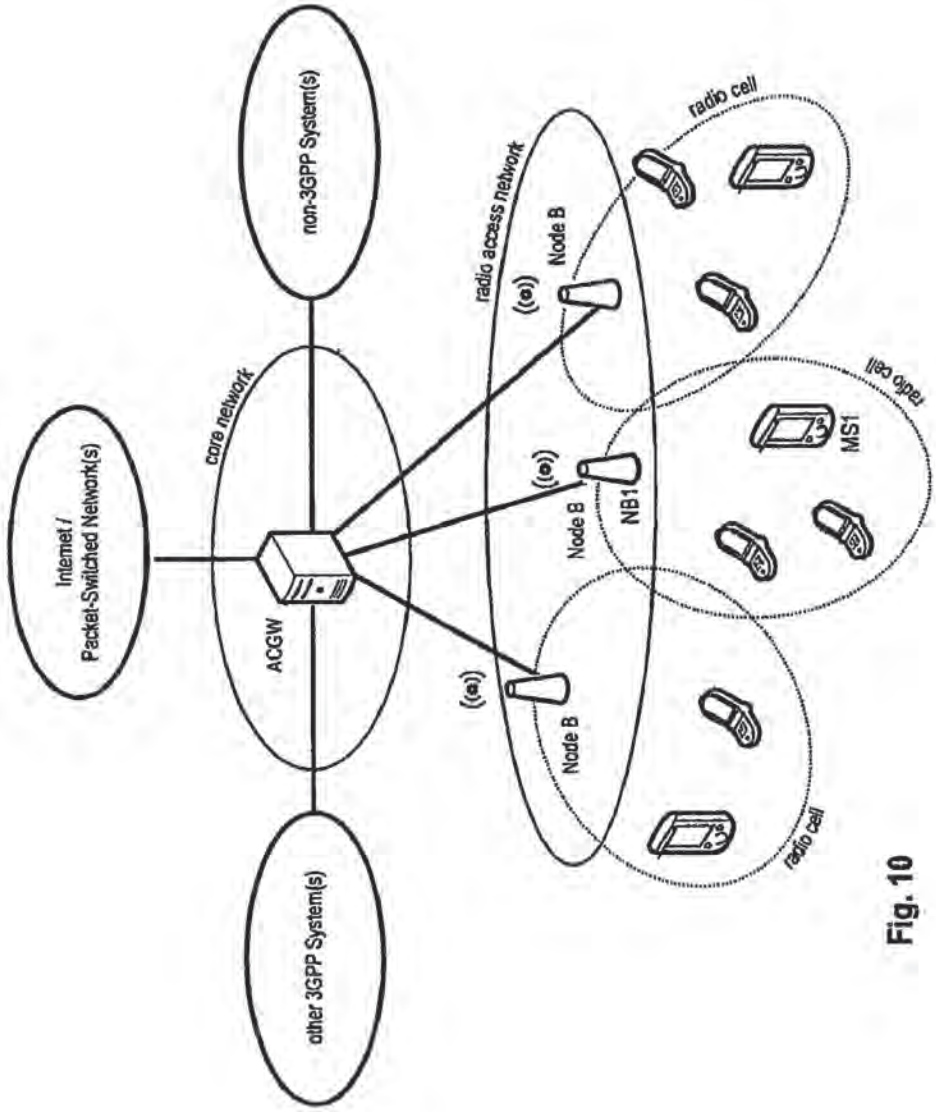

receiver
(e.g. mobile station MS1)
transmitter
(e.g. base station NB1)
L1/L2 control information 901
protocol data unit 902
„NACK" / No feedback 903
generate L1/L2 control information 904
L1/L2 control information 905
receive and interpret L1/L2 control information 906
protocol data unit 907
ACK 908

Fig. 9



non-3GPP System(s)
Internet /
Packet-Switched Network(s)
core network
ACGW
other 3GPP System(s)
radio access network
Node B
Node B
NB1
Node B
radio cell
radio cell
radio cell
MS1


Fig. 10

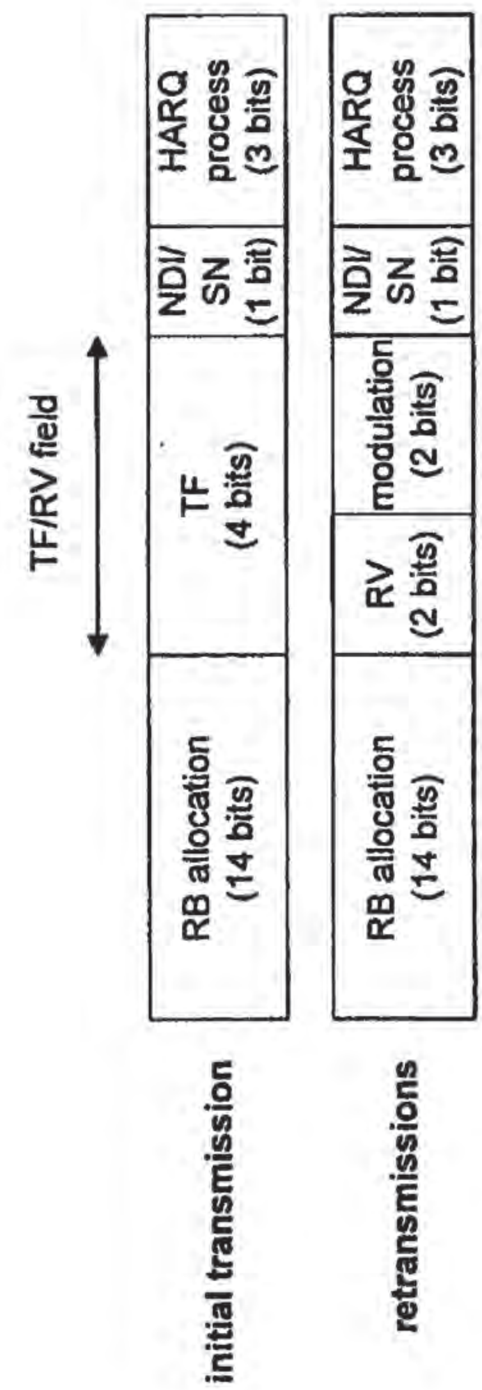

TF/RV field
initial transmission
RB allocation (14 bits)
TF (4 bits)
NDI/ SN (1 bit)
HARQ process (3 bits)
retransmissions
RB allocation (14 bits)
RV (2 bits)
modulation (2 bits)
NDI/ SN (1 bit)
HARQ process (3 bits)

Fig. 11

# CONTROL CHANNEL SIGNALING USING A COMMON SIGNALING FIELD FOR TRANSPORT FORMAT AND REDUNDANCY VERSION

## FIELD OF THE INVENTION

The invention relates to a method for providing control signalling associated to a protocol data unit conveying user data in a mobile communication system and to the control channel signal itself. Furthermore, the invention also provides a mobile station and a base station and their respective operation in view of the newly defined control channel signals defined herein.

## TECHNICAL BACKGROUND

Packet-Scheduling and Shared Channel Transmission

In wireless communication systems employing packet-scheduling, at least part of the air-interface resources are assigned dynamically to different users (mobile stations—MS or user equipments—UE). Those dynamically allocated resources are typically mapped to at least one Physical Uplink or Downlink Shared CHannel (PUSCH or PDSCH). A PUSCH or PDSCH may for example have one of the following configurations:

- One or multiple codes in a CDMA (Code Division Multiple Access) system are dynamically shared between multiple MS.
- One or multiple subcarriers (subbands) in an OFDMA (Orthogonal Frequency Division Multiple Access) system are dynamically shared between multiple MS.
- Combinations of the above in an OFCDMA (Orthogonal Frequency Code Division Multiplex Access) or a MC-CDMA (Multi Carrier-Code Division Multiple Access) system are dynamically shared between multiple MS.

FIG. 1 shows a packet-scheduling system on a shared channel for systems with a single shared data channel. A sub-frame (also referred to as a time slot) reflects the smallest interval at which the scheduler (e.g. the Physical Layer or MAC Layer Scheduler) performs the dynamic resource allocation (DRA). In FIG. 1, a TTI (transmission time interval) equal to one sub-frame is assumed. It should be born noted that generally a TTI may also span over multiple sub-frames.

Further, the smallest unit of radio resources (also referred to as a resource block or resource unit), which can be allocated in OFDM systems, is typically defined by one sub-frame in time domain and by one subcarrier/subband in the frequency domain. Similarly, in a CDMA system this smallest unit of radio resources is defined by a sub-frame in the time domain and a code in the code domain.

In OFCDMA or MC-CDMA systems, this smallest unit is defined by one sub-frame in time domain, by one subcarrier/subband in the frequency domain and one code in the code domain. Note that dynamic resource allocation may be performed in time domain and in code/frequency domain.

The main benefits of packet-scheduling are the multi-user diversity gain by time domain scheduling (TDS) and dynamic user rate adaptation.

Assuming that the channel conditions of the users change over time due to fast (and slow) fading, at a given time instant the scheduler can assign available resources (codes in case of CDMA, subcarriers/subbands in case of OFDMA) to users having good channel conditions in time domain scheduling.



Specifics of DRA and Shared Channel Transmission in OFDMA

Additionally to exploiting multi-user diversity in time domain by Time Domain Scheduling (TDS), in OFDMA multi-user diversity can also be exploited in frequency domain by Frequency Domain Scheduling (FDS). This is because the OFDM signal is in frequency domain constructed out of multiple narrowband subcarriers (typically grouped into subbands), which can be assigned dynamically to different users. By this, the frequency selective channel properties due to multi-path propagation can be exploited to schedule users on frequencies (subcarriers/subbands) on which they have a good channel quality (multi-user diversity in frequency domain).

For practical reasons in an OFDMA system the bandwidth is divided into multiple subbands, which consist out of multiple subcarriers. I.e. the smallest unit on which a user may be allocated would have a bandwidth of one subband and a duration of one slot or one sub-frame (which may correspond to one or multiple OFDM symbols), which is denoted as a resource block (RB). Typically, a subband consists of consecutive subcarriers. However, in some case it is desired to form a subband out of distributed non-consecutive subcarriers. A scheduler may also allocate a user over multiple consecutive or non-consecutive subbands and/or sub-frames.

For the 3GPP Long Term Evolution (3GPP TR 25.814: "Physical Layer Aspects for Evolved UTRA", Release 7, v. 7.1.0, October 2006—available at http://www.3gpp.org and incorporated herein by reference), a 10 MHz system (normal cyclic prefix) may consist out of 600 subcarriers with a subcarrier spacing of 15 kHz. The 600 subcarriers may then be grouped into 50 subbands (a 12 adjacent subcarriers), each subband occupying a bandwidth of 180 kHz. Assuming, that a slot has a duration of 0.5 ms, a resource block (RB) spans over 180 kHz and 0.5 ms according to this example.

In order to exploit multi-user diversity and to achieve scheduling gain in frequency domain, the data for a given user should be allocated on resource blocks on which the users have a good channel condition. Typically, those resource blocks are close to each other and therefore, this transmission mode is in also denoted as localized mode (LM).

An example for a localized mode channel structure is shown in FIG. 2. In this example neighboring resource blocks are assigned to four mobile stations (MS1 to MS4) in the time domain and frequency domain. Each resource block consists of a portion for carrying Layer 1 and/or Layer 2 control signaling (L1/L2 control signaling) and a portion carrying the user data for the mobile stations.

Alternatively, the users may be allocated in a distributed mode (DM) as shown in FIG. 3. In this configuration, a user (mobile station) is allocated on multiple resource blocks, which are distributed over a range of resource blocks. In distributed mode a number of different implementation options are possible. In the example shown in FIG. 3, a pair of users (MSs 1/2 and MSs 3/4) shares the same resource blocks. Several further possible exemplary implementation options may be found in 3GPP RAN WG#1 Tdoc R1-062089, "Comparison between RB-level and Sub-carrier-level Distributed Transmission for Shared Data Channel in E-UTRA Downlink", August 2006 (available at http://www.3gpp.org and incorporated herein by reference).

It should be noted, that multiplexing of localized mode and distributed mode within a sub-frame is possible, where the amount of resources (RBs) allocated to localized mode and distributed mode may be fixed, semi-static (constant for tens/hundreds of sub-frames) or even dynamic (different from sub-frame to sub-frame).

In localized mode as well as in distributed mode in a given sub-frame—one or multiple data blocks (which are inter alia referred to as transport-blocks) may be allocated separately to the same user (mobile station) on different resource blocks, which may or may not belong to the same service or Automatic Repeat reQuest (ARQ) process. Logically, this can be understood as allocating different users.

L1/L2 Control signaling

In order to provide sufficient side information to correctly receive or transmit data in systems employing packet scheduling, so-called L1/L2 control signaling (Physical Downlink Control CHannel—PDCCH) needs to be transmitted. Typical operation mechanisms for downlink and uplink data transmission are discussed below.

Downlink Data Transmission

Along with the downlink packet data transmission, in existing implementations using a shared downlink channel, such as 3GPP-based High Speed Data Packet Access (HSDPA), L1/L2 control signaling is typically transmitted on a separate physical (control) channel.

This L1/L2 control signaling typically contains information on the physical resource(s) on which the downlink data is transmitted (e.g. subcarriers or subcarrier blocks in case of OFDM, codes in case of CDMA). This information allows the mobile station (receiver) to identify the resources on which the data is transmitted. Another parameter in the control signaling is the transport format used for the transmission of the downlink data.

Typically, there are several possibilities to indicate the transport format. For example, the transport block size of the data (payload size, information bits size), the Modulation and Coding Scheme (MCS) level, the Spectral Efficiency, the code rate, etc. may be signaled to indicate the transport format (TF). This information (usually together with the resource allocation) allows the mobile station (receiver) to identify the information bit size, the modulation scheme and the code rate in order to start the demodulation, the de-rate-matching and the decoding process. In some cases the modulation scheme maybe signaled explicitly.

In addition, in systems employing Hybrid ARQ (HARQ), HARQ information may also form part of the L1/L2 signaling. This HARQ information typically indicates the HARQ process number, which allows the mobile station to identify the Hybrid ARQ process on which the data is mapped, the sequence number or new data indicator, allowing the mobile station to identify if the transmission is a new packet or a retransmitted packet and a redundancy and/or constellation version. The redundancy version and/or constellation version tells the mobile station, which Hybrid ARQ redundancy version is used (required for de-rate-matching) and/or which modulation constellation version is used (required for demodulation)

A further parameter in the HARQ information is typically the UE Identity (UE ID) for identifying the mobile station to receive the L1/L2 control signaling. In typical implementations this information is used to mask the CRC of the L1/L2 control signaling in order to prevent other mobile stations to read this information.

The table below (Table 1) illustrates an example of a L1/L2 control channel signal structure for downlink scheduling as known from 3GPP TR 25.814 (see section 7.1.1.2.3—FFS=for further study):

TABLE 1

| | Field | | Size | Comment |
|---|---|---|---|---|
| Cat. 1 (Resource indication) | ID (UE or group specific) | | [8-9] | Indicates the UE (or group of UEs) for which the data transmission is intended |
| | Resource assignment | | FFS | Indicates which (virtual) resource units (and layers in case of multi-layer transmission) the UE(s) shall demodulate. |
| | Duration of assignment | | 2-3 | The duration for which the assignment is valid, could also be used to control the TTI or persistent scheduling. |
| Cat. 2 (transport format) | Multi-antenna related information | | FFS | Content depends on the MIMO/beamforming schemes selected. |
| | Modulation scheme | | 2 | QPSK, 16 QAM, 64 QAM . . . In case of multi-layer transmission, multiple instances may be required. |
| | Payload size | | 6 | Interpretation could depend on e.g. modulation scheme and the number of assigned resource units (c.f. HSDPA). In case of multi-layer transmission, multiple instances may be required. |
| Cat. 3 (HARQ) | If asynchronous hybrid ARQ is adopted | Hybrid ARQ process number | 3 | Indicates the hybrid ARQ process the current transmission is addressing. |
| | | Redundancy version | 2 | To support incremental redundancy. |
| | | New data indicator | 1 | To handle soft buffer clearing. |
| | If synchronous hybrid ARQ is adopted | Retransmission sequence number | 2 | Used to derive redundancy version (to support incremental redundancy) and 'new data indicator' (to handle soft buffer clearing). |

Uplink Data Transmission

Similarly, also for uplink transmissions, L1/L2 signaling is provided on the downlink to the transmitters in order to inform them on the parameters for the uplink transmission. Essentially, the L1/L2 control channel signal is partly similar to the one for downlink transmissions. It typically indicates the physical resource(s) on which the UE should transmit the data (e.g. subcarriers or subcarrier blocks in case of OFDM, codes in case of CDMA) and a transport format the mobile station should use for uplink transmission. Further, the L1/L2 control information may also comprise Hybrid ARQ information, indicating the HARQ process number, the sequence number or new data indicator, and further the redundancy and/or constellation version. In addition, there may be a UE Identity (UE ID) comprised in the control signaling.

Variants

There are several different flavors how to exactly transmit the information pieces mentioned above. Moreover, the L1/L2 control information may also contain additional information or may omit some of the information. For example, the HARQ process number may not be needed in case of using no or a synchronous HARQ protocol. Similarly, the redundancy and/or constellation version may not be needed, if for example Chase Combining is used (i.e. always the same redundancy and/or constellation version is transmitted) or if the sequence of redundancy and/or constellation versions is pre-defined.

Another variant may be to additionally include power control information in the control signaling or MIMO related control information, such as e.g. pre-coding information. In case of multi-codeword MIMO transmission transport format and/or HARQ information for multiple code words may be included.

In case of uplink data transmission, part or all of the information listed above may be signaled on uplink, instead of on the downlink. For example, the base station may only define the physical resource(s) on which a given mobile station shall transmit. Accordingly, the mobile station may select and signal the transport format, modulation scheme and/or HARQ parameters on the uplink. Which parts of the L1/L2 control information is signaled on the uplink and which proportion is signaled on the downlink is typically a design issue and depends on the view how much control should be carried out by the network and how much autonomy should be left to the mobile station.

The table below (Table 2) illustrates an example of a L1/L2 control channel signal structure for uplink scheduling as known from 3GPP TR 25.814 (see section 7.1.1.2.3—FFS=for further study):

TABLE 2

| | Field | Size | Comment |
|---|---|---|---|
| Resource assignment | ID (UE or group specific) | [8-9] | Indicates the UE (or group of UEs) for which the grant is intended |
| | Resource assignment | FFS | Indicates which uplink resources, localized or distributed, the UE is allowed to use for uplink data transmission. |
| | Duration of assignment | 2-3 | The duration for which the assignment is valid. The use for other purposes, e.g., to control persistent scheduling, 'per process' operation, or TTI length, is FFS. |
| TF | Transmission parameters | FFS | The uplink transmission parameters (modulation scheme, payload size, MIMO-related information, etc) the UE shall use. If the UE is allowed to select (part of) the transport format, this field sets determines an upper limit of the transport format the UE may select. |

Another, more recent suggestion of a L1/L2 control signaling structure for uplink and downlink transmission may be found in 3GPP TSG-RAN WG1 #50 Tdoc. R1-073870, "Notes from offline discussions on PDCCH contents", August 2007, available at http://www.3gpp.org and incorporated herein by reference.

As indicated above, L1/L2 control signaling has been defined for systems that are already deployed to in different countries, such as for example, 3GPP HSDPA. For details on 3GPP HSDPA it is therefore referred to 3GPP TS 25.308, "High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2", version 7.4.0, September 2007 (available at http://www.3gpp.org) and Harri Holma and Antti Toskala, "WCDMA for UMTS, Radio Access For Third Generation Mobile Communications", Third Edition, John Wiley & Sons, Ltd., 2004, chapters 11.1 to 11.5, for further reading.

As described in section 4.6 of 3GPP TS 25.212, "Multiplexing and Channel Coding (FDD"), version 7.6.0, September 2007 (available at http://www.3gpp.org) in HSDPA the "Transport Format" (TF) (Transport-block size information (6 bits)), the "Redundancy and constellation Version" (RV/CV) (2 bits) and the "New Data Indicator" (NDI) (1 bit) are signaled separately by in total 9 bits. It should be noted that the NDI is actually serving as a 1-bit HARQ Sequence Number (SN), i.e. the value is toggled with each new transport-block to be transmitted.

## SUMMARY OF THE INVENTION

One object of the invention is to reduce the amount of bits required for control channel signaling, such as for example L1/L2 control signaling, in uplink or downlink. Further, it is desirable that such solution does further not introduce additional problematic HARQ protocol error cases.

The object is solved by the subject matter of the independent claims. Advantageous embodiments of the invention are subject matters of the dependent claims.

One main aspect of the invention is to suggest a new format for the control channel information. According to this aspect, the transport format/transport block size/payload size/modu-

lation and coding scheme and the redundancy version/constellation version for the associated transmission of the user data (typically in form of a protocol data unit or transport block) is provided in a single field of the control channel information. This single field is referred to as the control information field herein, but may for example also be denoted a transport format/redundancy version field or, in abbreviated form, a TF/RV field. In addition, some embodiment of the invention foresee to combine the transport format transport block size/payload size/modulation and coding scheme, the redundancy version/constellation version and additionally HARQ related information (sequence number or new data indicator) within a single field of the control channel information.

According to one embodiment, the invention provides a control channel signal (such as for example a L1/L2 control channel signal) for use in a mobile communication system. The control channel signal is associated to protocol data unit transporting user data and comprises a control information field consisting of a number of bits jointly encoding a transport format and a redundancy version used for transmitting the protocol data unit.

In one exemplary embodiment of the invention, the bits of the control information field jointly encode the transport format, a redundancy version used for transmitting the protocol data unit and a sequence number of the protocol data unit.

Further, in another exemplary embodiment, the bits of the control information field not only jointly encode the transport format and a redundancy version used for transmitting the protocol data unit, but further include a new data indicator for indicating whether the transmission of the protocol data unit is an initial transmission of the user data. Hence, in this example, a single field of the control channel signal is utilized to encode the three before mentioned control information related to the associated transmission of the user data.

According to another exemplary embodiment of the invention, the control information field consists of a number of bits yielding a range of values that can be represented in the control information field (e.g. if there are N bits provided in the field, $2^N$ different values may be represented in the field) and wherein a first subset of the values is reserved for indicating a transport format of the protocol data unit and a second subset of values are reserved for indicating a redundancy version for transmitting the user data. In one exemplary implementation, the first subset of values contains more values than the second subset of values.

Moreover, in another exemplary embodiment of the invention, the redundancy version of the protocol data unit is implicit to its transport format that indicated by the corresponding value of the first subset. In other words, each individual transport format that is represented by a specific bit combination of the first subset is univocally linked to a respective redundancy version so that no explicit signaling of the redundancy version of the protocol data unit is necessary. Another possibility would be that the redundancy version to be used for the initial transmission of the user data in the protocol data unit is fixed or preconfigured.

In another embodiment, it may be assumed that the transmission of the before-mentioned protocol data unit is an initial transmission of the user data. In this case, the value of the encoded information bits in the control channel field is representing a value of the first subset of values. Hence, in general, in case of an initial transmission, the transport format and optionally the redundancy version of the protocol data unit is indicated in the control channel signal. As indicated previously, the redundancy version may also be implicit to the transport format.

In a similar fashion, in case the transmission of the protocol data unit is a retransmission of the user data, the value of the encoded information bits in the control channel field is representing a value of the second subset of values. This may be for example advantageous in a system design, where the transport format (e.g. transport block size) of a protocol data unit does not change between initial transmission and retransmission or if the transport format can be determined from the transport format and the resource allocation information for the initial transmission and the resource allocation information for the retransmission. Accordingly, if a retransmission needs to be sent for the user data, the control channel signal for this retransmission does not need to explicitly signal the transport format for the retransmitted protocol data unit, but rather the bits of the control information field indicate the redundancy version of the protocol data unit, while assuming the transport format of the retransmission to be the same as for the initial transmission or to be determined from the transport format and (optionally) the resource allocation information of the initial transmission and, optionally further, the resource allocation information in the retransmission.

However, in other exemplary designs, the transport format of the initial transmission of the user data may not be known, e.g. in case the receiving terminal has missed the transmission of the control channel signal, or the same transport format can no longer be used for the retransmission, e.g. due to a reconfiguration of resources allocated to the transmission of the protocol data unit. Accordingly, in another embodiment of the invention, in case the transmission of the protocol data unit is a retransmission of the user data, the value of the encoded information bits in the control channel field is representing a value of the first subset or the second subset of values.

Hence, in this example, the control information field may either indicate the redundancy version of the protocol data unit, while assuming the transport format of the retransmission to be known from the initial transmission, or a transport format (and implicitly or explicitly the redundancy version) for the retransmission may be indicated in the retransmission, as appropriate.

Another exemplary embodiment, the transport format, a redundancy version used for transmitting the protocol data unit and a new data indicator for indicating whether the transmission of the protocol data unit is an initial transmission of the user data are assumed to be jointly encoded in the control information field, while the values that can be represented by the control information field bits are again split into a first and second subset in a similar fashion as described above. In this example, use of one of the values of a first subset set also indicates the transmission of the protocol data unit to be an initial transmission. I.e. in this case the values of the first subset may be considered a new data indicator being set, i.e. indicating an initial transmission, while the values of the second subset may be considered a new data indicator not being set, i.e. indicating a retransmission.

In case the sequence number/new data indicator is not jointly encoded together with the transport format and the redundancy version, in an alternative embodiment of the invention, a respective field may be realized in the control channel signal.

According to a further embodiment of the invention, the control channel signal comprises a resource allocation field for indicating the physical radio resource or resources allocated to a receiver for receiving the protocol data unit or the physical radio resource or resources on which a transmitter is to transmit the protocol data unit.

In another embodiment, the control channel signal further comprises a mobile terminal identifier field for indicating the

mobile terminal or a group of mobile terminals that are to receive the control channel signal.

In a further embodiment of the invention, the control channel signal or rather the bits of the control information field include a flag indicating the type of information indicated by the remaining bits of the control information field, in case the protocol data packet is a retransmission for the user data.

In an alternative solution according to another embodiment of the invention, another control channel signal is provided. Also this alternative control channel signal is associated to protocol data unit transporting user data and comprises a control information field consisting of a number of bits representing a transport format and implicitly a redundancy version of the protocol data unit, if the transmission of the protocol data unit is an initial transmission of the user data, or representing a redundancy version of the protocol data unit, if the transmission of the protocol data unit is a retransmission of the user data.

Further, in a variation of this embodiment, the bits of the control information field represent a redundancy version and optionally a transport format of the protocol data unit, if the transmission of the protocol data unit is a retransmission.

Another embodiment of the invention relates to a method for encoding control signaling associated to a protocol data unit conveying user data in a mobile communication system. In this method, the base station generates a control channel signal comprising a control information field in which a transport format and a redundancy version of the protocol data unit is jointly encoded, and subsequently transmits the control channel signal to at least one mobile terminal.

In a further embodiment, the base station receives feedback from the at least one mobile terminal. The feedback indicates whether the protocol data unit has been successfully decoded at the mobile terminal. If no successful decoding has been possible, the base station may retransmit the protocol data unit and may further transmit a second control channel signal comprising a control information field in which a transport format and a redundancy version of the protocol data unit is jointly encoded. Thereby, the second control channel signal is associated to a retransmission of the protocol data unit to the mobile terminal.

In one exemplary embodiment, the protocol data unit and the second protocol data unit are transmitted or received using the same HARQ process.

Another embodiment of the invention relates to a method for providing control signaling associated to a protocol data unit conveying user data in a mobile communication system. According to this method, a base station of the mobile communication system generates a control channel signal that comprises a control information field consisting of a number of bits representing:

- a transport format and implicitly a redundancy version of the protocol data unit, if the transmission of the protocol data unit is an initial transmission of the user data, or
- a redundancy version of the protocol data unit, if the transmission of the protocol data unit is a retransmission of the user data.

Subsequently the base station transmits the control channel signal to at least one mobile terminal.

In a further embodiment of the invention, in both methods mentioned above, the base station may also transmit the protocol data unit to a mobile terminal or receiving the protocol data unit from the mobile terminal utilizing a HARQ retransmission protocol. In one example, the protocol data unit is transmitted or received using a HARQ process indicated in the control channel signal. In another example, the protocol data unit is transmitted or received using a HARQ process determined based on to the sub-frame number of the sub-frame conveying the protocol data unit. The protocol data unit may be transmitted or received using the physical radio resource or resources indicated in the control channel signal.

In one exemplary embodiment of the invention the mobile communication system is a multi-carrier system, such as for example an OFDM-based system, and the control channel signal is transmitted within the physical radio resources of a sub-frame allocated to the L1/L2 control channels of the multi-carrier system.

Furthermore, in another exemplary embodiment of the invention the protocol data unit is transmitted in the same sub-frame as the associated control channel signal.

Though the exemplary embodiments described herein are mainly focusing on outlining the relation between one base station and one mobile terminal, it is apparent that the base station may be serving a plurality of mobile terminals, and a control channel signal is generated and transmitted by the base station for each mobile terminal or group of mobile terminals.

A further embodiment of the invention is related to the operation of the mobile terminal. Accordingly, a method is provided in which a mobile terminal receive a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal. The control channel signal comprises a control information field in which a transport format and a redundancy version of a protocol data unit are jointly encoded. The mobile terminal next determines the transport format and the redundancy version for the protocol data packet conveying user data based on the received control channel signal, and receives or transmits the protocol data packet on at least one physical radio resource using the transport format and the redundancy version of the protocol data packet indicated in the received control information field.

In one example, the transport format is transport block size information of the protocol data unit, and the received control channel signal comprises a resource allocation field indicating the physical radio resource or resources allocated to the mobile terminal. Accordingly, the mobile terminal may determine the transport block size of the protocol data unit depending on the information comprised in the resource allocation field and the control information field.

In another example, the control channel signal indicates the protocol data packet to be a retransmission (e.g. new data indicator not set) of user data and wherein the method further comprises the step of transmitting a positive acknowledgment for the received protocol data packet to the base station, if the control channel signaling associated to the initial transmission for the user data has been missed. Hence, even though the mobile terminal has not received the control channel signal and could not receive the associated transmission of the user data, the mobile terminal may acknowledge "successful reception" of the user data and may for example rely on upper layer protocols, such as for example the Radio Link Control (RLC) protocol, to take care of handling retransmission.

In case the protocol data unit is a retransmission, according to another example, the mobile terminal may reuse the transport format information of the protocol data unit indicated in a control channel signal for the initial transmission for the transmission or reception of the retransmission of the protocol data unit. Accordingly, the control channel signal may be "only" indicating the redundancy version of the retransmission (though one may still consider the control channel signal to implicitly indicate the transport format).

In another exemplary embodiment of the invention, the information bits in the control information field of the control channel signal are associated to a single reference informa-

tion indicating a transport format and a redundancy version used for transmitting the protocol data unit associated to the respective value represented by the information bits of the control information field for initial transmissions and retransmissions of the protocol data packet.

In a further embodiment of the invention relates to the operation of the mobile terminal. In this embodiment, the mobile terminal receives a sub-frame of physical radio resources comprising a control channel signal. The control channel signal thereby comprises a control information field consisting of a number of bits representing:

a transport format and implicitly a redundancy version of the protocol data unit, if the transmission of the protocol data unit is an initial transmission of the user data, or

a redundancy version of the protocol data unit, if the transmission of the protocol data unit is a retransmission of the user data.

Next, the mobile terminal determines (based on the received control channel signal) the transport format of and the redundancy version for the protocol data packet conveying user data, and further receive or transmits the protocol data packet on at least one physical radio resource using the transport format and the redundancy version of the protocol data packet indicated in the received control information field.

In this exemplary embodiment, the information bits of the control information are associated to two different reference information (based on which the control information field content is interpreted). If the transmission of the protocol data packets is an initial transmission, the first reference information is utilized when determining the transport format and the redundancy version of the protocol data packet. If the transmission of the protocol data packets is a retransmission, the second reference is used when determining the transport format and the redundancy version of the protocol data packet.

In one example, the first reference information indicates a transport format associated to the respective value represented by the information bits of the control information field, and the second reference information indicates a redundancy version associated to the respective value represented by the information bits of the control information field.

Another embodiment of the invention provides a base station for providing control signaling associated to a protocol data unit conveying user data in a mobile communication system. The base station comprises a processing unit for generating a control channel signal comprising a control information field in which a transport format and a redundancy version of the protocol data unit is jointly encoded, and a transmitter unit transmitting control signaling comprising the control channel signal to at least one mobile terminal.

Further, another embodiment of the invention relates to a mobile terminal for use in a mobile communication system, whereby the mobile terminal comprises a receiver unit for receiving a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal. The control channel signal comprises a control information field in which a transport format and a redundancy version of a protocol data unit is jointly encoded, as mentioned previously herein. The mobile terminal also comprises a processing unit for determining based on the received control channel signal the transport format of and the redundancy version for the protocol data packet conveying user data, and a transmitter unit for transmitting the protocol data packet on at least one physical radio resource using the transport format and the redundancy version of the protocol data packet indicated in the received control information field.

In an alternative embodiment, the mobile terminal comprises a receiver unit for receiving a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal, and a processing unit for determining based on the received control channel signal the transport format of and the redundancy version for the protocol data packet conveying user data. Furthermore, the receiver unit is capable of receiving the protocol data packet on at least one physical radio resource using the transport format and the redundancy version of the protocol data packet indicated in the received control information field.

Moreover, the invention according to other exemplary embodiments relates to the implementation of the methods described herein in software and hardware. Accordingly, another embodiment of the invention provides a computer readable medium storing instructions that, when executed by a processor unit of a base station, cause the base station to generate a control channel signal comprising a control information field in which a transport format and a redundancy version of the protocol data unit is jointly encoded, and to transmit the control channel signal to at least one mobile terminal.

A further embodiment relates to a computer readable medium storing instructions that, when executed by a processor unit of a mobile terminal, cause the mobile terminal to receive a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal, determine based on the received control channel signal the transport format of and the redundancy version for the protocol data packet conveying user data, and receive or transmit the protocol data packet on at least one physical radio resource using the transport format and the redundancy version of the protocol data packet indicated in the received control information field.

## BRIEF DESCRIPTION OF THE FIGURES

In the following, the invention is described in more detail in reference to the attached figures and drawings. Similar or corresponding details in the figures are marked with the same reference numerals.

FIG. 1 shows an exemplary data transmission to users in an OFDMA system in localized mode (LM) having a distributed mapping of L1/L2 control signaling,

FIG. 2 shows an exemplary data transmission to users in an OFDMA system in localized mode (LM) having a distributed mapping of L1/L2 control signaling,

FIG. 3 shows an exemplary data transmission to users in an OFDMA system in distributed mode (DM) having a distributed mapping of L1/L2 control signaling,

FIG. 4 exemplarily highlights the interrelation between transport block/protocol data unit and its different redundancy versions as well as the transport block size/protocol data unit size,

FIG. 5 shows an example of a control channel signal with a common field for jointly encoding transmission format and redundancy version of a protocol data unit according to one embodiment of the invention,

FIG. 6 shows an example of a control channel signal with a common, shared field for signaling the transmission format or the redundancy version of a protocol data unit according to one embodiment of the invention,

FIG. 7 shows another example of a control channel signal with a common, shared field for signaling the transmission format, the redundancy version or other information for a protocol data unit according to one embodiment of the invention,

FIG. 8 shows an exemplary, typical message flow between a transceiver and receiver of a control channel signal according to an exemplary embodiment of the invention,

FIG. 9 shows an exemplary message flow between a transceiver and receiver of a control channel signal in which the retransmission protocol operation of the receiver is optimized according to an exemplary embodiment of the invention,

FIG. 10 shows a mobile communication system according to one embodiment of the invention, in which the ideas of the invention may be implemented, and

FIG. 11 shows another example of a control channel signal with a common, shared field for signaling the transmission format or the redundancy version of a protocol data unit according to one embodiment of the invention,

## DETAILED DESCRIPTION OF THE INVENTION

The following paragraphs will describe various embodiments of the invention. For exemplary purposes only, most of the embodiments are outlined in relation to an (evolved) UMTS communication system according to the SAE/LTE discussed in the Technical Background section above. It should be noted that the invention may be advantageously used for example in connection with a mobile communication system such as the SAE/LTE communication system previously described or in connection with multi-carrier systems such as OFDM-based systems, but the invention is not limited to its use in this particular exemplary communication network.

Before discussing the various embodiments of the invention in further detail below, the following paragraphs will give a brief overview on the meaning of several terms frequently used herein and their interrelation and dependencies. Generally, a protocol data unit may be considered a data packet of a specific protocol layer that is used to convey one or more transport blocks. In one example, the protocol data unit is a MAC Protocol Data Unit (MAC PDU), i.e. a protocol data unit of the MAC (Medium Access Control) protocol layer. The MAC PDU conveys data provided by the MAC layer to the PHY (Physical) layer. Typically, for a single user allocation (one L1/L2 control channel—PDCCH—per user), one MAC PDU is mapped onto one transport block (TB) on Layer 1. A transport block defines the basic data unit exchanged between Layer 1 and MAC (Layer 2). Typically, the when mapping a MAC PDU onto a transport block one or multiple CRCs are added. The transport block size is defined as the size (number of bits) of a transport block. Depending on the definition, the transport size may include or exclude the CRC bits. in general, the transport format defines the modulation and coding scheme (MCS) and/or the transport block size, which is applied for the transmission of a transport block and is, therefore, required for appropriate (de)modulation and (de) coding. In a 3GPP-based system as for example discussed in 3GPP TR 25.814, the following relationship between the modulation and coding scheme, the transport block size and the resource allocation size is valid:

$$TBS=CR\cdot M\cdot N_{RE}$$

where $N_{RE}$ is the number of allocated resource elements (RE)—one RE being identical to one modulation symbol—, CR is the code rate for encoding the transport block, and M is the number of bits mapped onto one modulation symbol, e.g. M=4 for 16-QAM.

Due to this relationship described above, the L1/L2 control signaling may only need to indicate either the transport block size or the modulation and coding scheme. In case the modulation and coding scheme should be signaled, there are several options how to implement this signaling. For example, separate fields for modulation and coding or a joint field for signaling both, the modulation and coding parameters may be foreseen. In case the transport block site should be signaled, the transport block size is typically not explicitly signaled, but is rather signaled as a TBS index. The interpretation of the TBS index to determine the actual transport block size may for example depend on the resource allocation size.

In the following, the transport format field on the L1/L2 control signaling is assumed to be indicating either the modulation and coding scheme or the transport block size. It should be noted, that the transport block size for a given transport block typically does not change during transmissions. However, even if the transport block size is not changed, the modulation and coding scheme may change between transmissions, e.g. if the resource allocation size is changed (as apparent for the described relationship above).

It should be also noted that in some embodiments of the invention, for retransmissions the transport block size is typically known from the initial transmission. Therefore, the transport format (MCS and/or TBS) information (even if the modulation and coding scheme changes between transmissions) does not have to be signaled in retransmissions, since the modulation and coding scheme can be determined from the transport block size and the resource allocation size, which can be determined from the resource allocation field.

A redundancy version denotes a set of encoded bits generated from a given transport block, as shown in FIG. 4. In systems, where the code rate for the data transmission is generated by a fixed rate encoder and a rate matching unit (e.g. in HSDPA of UMTS or LTE systems), different redundancy versions are generated for a single transport block (or protocol data unit) by selecting different sets of available encoded bits, where the set size (number of selected bits) depends on the actual code rate (CR) for the data transmission. In case the actual code rate for a transmission (or retransmission) is higher than the encoder rate, a redundancy version is constructed out of a subset of encoded bits. In case the actual code rate for a transmission (or retransmission) is lower than the encoder rate, a redundancy version is typically constructed out of all encoded bits with selected bits being repeated.

A constellation version denotes the constellation diagram being applied for the modulation of the data transmission. In some cases, this may simply refer to a specific bit-to-symbol mapping for a given modulation scheme. In other cases, this may refer to a specific bit operations by interleaving and/or inversion of bit values in order to achieve a similar effect as by applying a specific bit-to-symbol mapping (see for example EP 1 293 059 B1 or EP 1 313 248 B1 or 3GPP TS 25.212, "Multiplexing and Channel Coding (FDD"), version 7.6.0, September 2007 available at http://www.3gpp.org)

A New Data Indicator (NDI) denotes a flag (or field) indicating whether a transmission of a transport block (or protocol data unit) is an initial transmission or a retransmission. If the NDI is set, the transmission of a transport block (or protocol data unit) is an initial transmission. In some implementations, the new data indicator is a 1-bit sequence number (SN), which is incremented every other transport block (or protocol data unit). In case of using a single bit for the NDI/SN the increment is identical to toggling the bit. Generally, however, a sequence number may comprise more than one bit.

One main aspect of the invention is to suggest a new format for the control channel information. According to this aspect, the transport format/transport block size/payload size/modulation and coding scheme and the redundancy version/con-

stellation version for the associated transmission of the user data (typically in form of a protocol data unit) is provided in a single field of the control channel information. The control channel information may for example be L1/L2 control information/a L1/L2 control channel signal that is transmitted on the PDCCH (Physical Downlink Control CHannel) of a 3GPP LTE system.

It should be noted that for simplicity it is referred to transport format and redundancy version in most of the examples herein. However, in all embodiments of this invention the term "transport format" means either one of "transport format", "transport block size", "payload size" or "modulation and coding scheme". Similarly, in all embodiments of this invention the term "redundancy version" can be replaced by "redundancy version and/or constellation version".

In addition, some embodiment of the invention foresee to combine the transport format, the redundancy version and additionally HARQ related information ((Retransmission/HARQ) sequence number or new data indicator NDI) within a single field of the control channel information.

There are two basic approaches suggested herein. According to different embodiments of the invention, a joint encoding of transport format and redundancy version is provided or alternatively a shared signaling of transport format and redundancy version is used. In both cases, only a single control channel information field is provided for the transport format and the redundancy version, however the use of the filed is different.

When using joint encoding, there is one common field for the transport format and the redundancy version defined in the control channel information/signal. The transport format and redundancy version are jointly coded, e.g. a field of N bits is used yielding $2^N$ values, which can be signaled. Out of the $2^N$ values M ($<2^N$) values are used to indicate a transport format which is for example associated to a given fixed or pre-configured redundancy version (In this case one could speak of an explicit signaling of the transport format and a simultaneous implicit signaling of the redundancy version). All or part of the remaining values is used to indicate additional redundancy versions that may be for example used for retransmissions of the protocol data unit.

The latter may for example be especially applicable in a system design, where the transport format of a transport block/protocol data unit does not change between initial and retransmission or can be derived from other information in the control channel signal for the retransmission and/or the initial transmission (for example, in some systems it may be possible to derive the transport format of a retransmission from the transport format and optionally resource allocation information related to the initial transmission—further also the information on the resource allocation for the retransmission may be taken into account). In this example, the control signaling for the retransmission may explicitly indicate the redundancy version of the protocol data unit used for its retransmission and implicitly yielding the transport format (i.e. the same transport format as used for the initial transmission of the protocol data unit that has been indicated in a previous control channel signal for the initial transmission or the transport format can be derived from other control channel signaling information as mentioned above).

As mentioned previously, as an additional enhancement, the new data indicator or sequence number may be additionally jointly coded with the transport format and redundancy version.

Utilizing the second approach of having a shared field for the transport format and the redundancy version defined in the control channel information structure, at one signaling instant the shared field is used to signal the transport format and at another signaling instant the shared field is used to signal the redundancy version.

Accordingly, when jointly encoding the transport format and the redundancy version only on single set of reference information to map the bit value indicated by the bit combination in the common control information field in the control channel signal to a respective combination of transport format and redundancy version of the protocol data unit providing the user data may be needed, irrespective of whether the transmission is an initial transmission of the protocol data unit or a retransmission thereof.

In case of having a shared control information field in the control channel signal, there may be two sets of reference information to map the bit value indicated by the bit combination in the common control information field to a respective combination of transport format and redundancy version, depending on whether the transmission is an initial transmission of the protocol data unit or a retransmission thereof. For example, in case there is a pre-configured or fixed redundancy version for the initial transmission, the control channel signal for the initial transmission may explicitly indicate the transport format of the initial transmission within the shared field. For some retransmissions, the transport format of the initial transmission may be reused, so that the control channel signal for the retransmission may "only" explicitly indicate the redundancy version of the retransmission (while the transport format may be considered implicitly identified or known from the control channel signal for the initial or any previous transmission).

One significant difference between the general concept of the invention and existing systems, such as 3GPP HSDPA, from the viewpoint of an efficient system operation is related to HARQ protocol errors. In HSDPA a lost transport block (MAC PDU), e.g. due to an ACK/NACK misdetection or a lost L1/L2 downlink control signaling carrying the scheduling information (TF, HARQ, etc.), comes at a high resource cost and high delay, since the RLC protocol taking care of these errors is slow and heavy. In LTE systems (which is one of the target systems for employing the this invention), the higher-layer RLC protocol is lightweight and fast, which allows designing the L1/L2 downlink control signaling to be less robust, which in turn allows for optimizations disclosed herein. As indicated above, one approach suggested herein is the use of a single/common field in the control channel information format to indicate the transport format and (at least implicitly) the redundancy version of the transmission of a protocol data unit and to jointly encode (at least) these two parameters using the bits of the common field. According to one exemplary embodiment of the invention, the common field in the control channel information may be assumed to consist of N bits so that $2^N$ values can be represented and signaled. Out of the $2^N$ values M ($<2^N$) values may be for example used to indicate a transport format associated with a given fixed or pre-configured redundancy version. All or part of the remaining values is/are used to indicate additional redundancy versions.

Table 3 below illustrates an example, where the common field (Signaled Value) consists of 4 bits. The first part (denoted TF range) of the total range of values representable by the 4 bits is used to indicate different transport formats that are associated to a given redundancy version (RV 0). The remaining values representable by the 4 bits form a second part (denoted RV range) and indicate a redundancy version of the respective transmission.

TABLE 3

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) | RV | Ranges |
|---|---|---|---|---|
| 0000 | 0 | | 0 | TF range |
| 0001 | 1 | — | 0 | |
| 0010 | 2 | — | 0 | |
| 0011 | 3 | — | 0 | |
| 0100 | 4 | — | 0 | |
| 0101 | 5 | 100 | 0 | |
| 0110 | 6 | 120 | 0 | |
| 0111 | 7 | 150 | 0 | |
| 1000 | 8 | 200 | 0 | |
| 1001 | 9 | — | 0 | |
| 1010 | 10 | — | 0 | |
| 1011 | 11 | — | 0 | |
| 1100 | 12 | — | 0 | |
| 1101 | 13 | NA | 1 | RV range |
| 1110 | 14 | | 2 | |
| 1111 | 15 | | 3 | |

In Table 3 above, all values of the TF range are assigned to a single redundancy version (RV 0) only. Of course, it may be also possible that the respective values/transport formats are associated to different redundancy versions. This is exemplified in FIG. 4 below.

TABLE 4

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) | RV | Ranges |
|---|---|---|---|---|
| 0000 | 0 | — | 0 | TF range |
| 0001 | 1 | — | 0 | |
| 0010 | 2 | — | 0 | |
| 0011 | 3 | — | 0 | |
| 0100 | 4 | — | 1 | |
| 0101 | 5 | 100 | 1 | |
| 0110 | 6 | 120 | 1 | |
| 0111 | 7 | 150 | 1 | |
| 1000 | 8 | 200 | 2 | |
| 1001 | 9 | — | 2 | |
| 1010 | 10 | — | 2 | |
| 1011 | 11 | — | 2 | |
| 1100 | 12 | | 2 | |
| 1101 | 13 | NA | 0 | RV range |
| 1110 | 14 | | 1 | |
| 1111 | 15 | | 2 | |

According to the example in Table 4, redundancy versions may be defined depending on the actual signaling value. In one embodiment, for small transport block sizes or low MCS levels, one specific redundancy version (RV 0) could be used and for larger transport block sizes/high MCS levels, another redundancy version (RV 1 or RV 2) are used. Furthermore, in another example, the same transport format may be associated to different redundancy versions.

In operation, when initially transmitting a protocol data unit (or transport block), the base station may send a control channel signal comprising a common TF/RV field having a value selected from the "TF range". Accordingly, the signaled value does not only identify a transport format of the protocol data unit but also indicates the respective redundancy version. If a protocol data unit is retransmitted, a value from the "RV range" indicating a specific redundancy version is signaled, as it may be assumed that the transport format is constant or known for all transmissions of a respective protocol data unit (transport block) to facilitate soft-combining by the HARQ protocol.

Alternatively, e.g. depending on the feedback of the receiver (e.g. the mobile station) of the protocol data unit provided to the transmitter (e.g. the base station) of the protocol data unit, the transmitter may decide to send the retransmission with the same transport format and redundancy version as the initial transmission. Using a reference table as shown in Table 3, the control channel signal for the retransmission may thus indicate the same value in the TF/RV field of the control channel signal as the control channel signal for the initial transmission (as the "RV range" does not allow to signal RV 0). If using a reference table as shown in Table 4, it should be noted that the "RV range" yields three the same three redundancy versions that are identified in the "TF range", so that the TF/RV field in the control channel signal may always a value of the "RV range" for the retransmissions.

In case there should be the possibility to send retransmissions with the same redundancy version as the initial transmission, e.g. due to using HARQ with Chase combining as a retransmission protocol for the protocol data units the following exemplary implementations may be foreseen.

In one exemplary implementation, any "TF range" value can be signaled in the control channel signal for retransmissions, even if the signaled value does not matching the TF (TBS) value of the transport block (or in other words the TF of the initial transmission of the protocol data unit). In this case, the receiver (e.g. mobile station) simply ignores the transport format that would be yielded by the signaled "TF range" value, and simply applies the signaled redundancy version. Accordingly, in order to distinguish when to ignore the signaled transport format, the receiver may evaluate the sequence number (field) or new data indicator first, so as to recognize whether the associated transmission of the protocol data unit is an initial transmission or a retransmission.

In another, second exemplary implementation, also for a retransmission the "TF range" value can be signaled that is matching the transport format (TBS) of the first, initial transmission. In this case, the receiver (e.g. mobile station) shall typically not ignore the signaled transport format (TBS) value, as this might help to discover error cases. If for example the receiver has missed the control signaling of the initial transmission (and hence missed also the first transmission of the protocol data unit/transport block), the receiver may try to decode the data based on the signaling for the retransmission, since the control signaling contains the transport format.

In a third exemplary implementation, the interpretation of the transport format (TBS) value in the common TF/RV field depends on the resource allocation field also comprised in the control channel information. This means that for a given resource allocation size, only a specific range of transport block sizes may be signaled (typically, the transport block size TBS is related to the amount of allocated resources—measured in resource blocks RBs—as follows: TBS=N·RB, where N=1, 2, 3, . . . ). In case the resource allocation size changes between initial transmission and retransmissions, it may happen that it is not possible to signal the correct transport block size. In this case, it may be advantageous to include an "Out of Range" TF value in the reference table used at the receiver of the control channel signal to interpret the content of the TF/RV field. This latter case is exemplified in Table 5 below.

TABLE 5

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) | RV | Ranges |
|---|---|---|---|---|
| 0000 | 0 | — | 0 | TF range |
| 0001 | 1 | — | 0 | |
| 0010 | 2 | — | 0 | |
| 0011 | 3 | — | 0 | |
| 0100 | 4 | — | 0 | |
| 0101 | 5 | 100 | 0 | |

TABLE 5-continued

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) | RV | Ranges |
|---|---|---|---|---|
| 0110 | 6 | 120 | 0 | |
| 0111 | 7 | 150 | 0 | |
| 1000 | 8 | 200 | 0 | |
| 1001 | 9 | — | 0 | |
| 1010 | 10 | — | 0 | |
| 1011 | 11 | — | 0 | |
| 1100 | 12 | "Out of Range" | 0 | |
| 1101 | 13 | NA | 1 | RV range |
| 1110 | 14 | | 2 | |
| 1111 | 15 | | 3 | |

In another, fourth exemplary implementation, it may be ensured that the same redundancy version as used for a initial transmission may be used for a retransmission by having including in the "RV range" a value that yields the same redundancy version as yielded by the values of the "TF range". This implementation is exemplified in Table 6 below, where the "RV range" also comprises a value ("1101") that is indicating use of redundancy RV 0.

TABLE 6

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) | RV | Ranges |
|---|---|---|---|---|
| 0000 | 0 | — | 0 | TF range |
| 0001 | 1 | — | 0 | |
| 0010 | 2 | — | 0 | |
| 0011 | 3 | — | 0 | |
| 0100 | 4 | — | 0 | |
| 0101 | 5 | 100 | 0 | |
| 0110 | 6 | 120 | 0 | |
| 0111 | 7 | 150 | 0 | |
| 1000 | 8 | 200 | 0 | |
| 1001 | 9 | — | 0 | |
| 1010 | 10 | — | 0 | |
| 1011 | 11 | — | 0 | |
| 1100 | 12 | — | 0 | |
| 1101 | 13 | NA | 0 | RV range |
| 1110 | 14 | | 1 | |
| 1111 | 15 | | 2 | |

In another embodiment of the invention, the control channel signal also includes a new data indicator (indicating whether the data is new data/a new protocol data unit) or a sequence number of the protocol data unit, which allows the receiver to detect the transmission of new data/a new protocol data unit.

According to one example, the new data indicator or the sequence number may be transmitted in a separate field or flag in the control channel signal. In one exemplary implementation the sequence number field is one bit, i.e. incrementing is identical to toggling the flag. Similarly, the new data indicator may be implemented as a 1-bit field. In case, a new transport block is transmitted (initial transmission) the new data indicator value is set (e.g. to value 1) and, if a transport block is retransmitted, the new data indicator is not set (e.g. is set to value 0).

According to another exemplary implantation, the sequence number or new data indicator is jointly encoded together with the transport format and the redundancy version in a single, common field of the control channel signal. Hence, the NDI/SN field may be no longer required, which allows to reduce signaling overhead.

The joint encoding of the new data indicator (NDI) with the transport format and the redundancy version according to two exemplary embodiments of the invention is shown in Table 7 and Table 8. In Table 8, the use of redundancy version RV 0 may be considered to implicitly also indicate new data, i.e. could therefore also be interpreted as a NDI flag being set (e.g. NDI=1), and all other redundancy versions RVs (RV 1-3) indicate retransmissions, i.e. could be also interpreted as the NDI flag not being set (e.g. NDI=0)

TABLE 7

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) | RV | NDI | Ranges |
|---|---|---|---|---|---|
| 0000 | 0 | — | 0 | 1 | TF range |
| 0001 | 1 | — | 0 | 1 | (new data range) |
| 0010 | 2 | — | 0 | 1 | |
| 0011 | 3 | — | 0 | 1 | |
| 0100 | 4 | — | 0 | 1 | |
| 0101 | 5 | 100 | 0 | 1 | |
| 0110 | 6 | 120 | 0 | 1 | |
| 0111 | 7 | 150 | 0 | 1 | |
| 1000 | 8 | 200 | 0 | 1 | |
| 1001 | 9 | — | 0 | 1 | |
| 1010 | 10 | — | 0 | 1 | |
| 1011 | 11 | — | 0 | 1 | |
| 1100 | 12 | — | 0 | 1 | |
| 1101 | 13 | NA | 0 | 0 | RV range |
| 1110 | 14 | | 1 | 0 | (retransmission |
| 1111 | 15 | | 2 | 0 | range) |

TABLE 8

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) | RV | NDI | Ranges |
|---|---|---|---|---|---|
| 0000 | 0 | — | 0 | 1 | TF range |
| 0001 | 1 | — | 0 | 1 | (new data range) |
| 0010 | 2 | — | 0 | 1 | |
| 0011 | 3 | — | 0 | 1 | |
| 0100 | 4 | — | 0 | 1 | |
| 0101 | 5 | 100 | 0 | 1 | |
| 0110 | 6 | 120 | 0 | 1 | |
| 0111 | 7 | 150 | 0 | 1 | |
| 1000 | 8 | 200 | 0 | 1 | |
| 1001 | 9 | — | 0 | 1 | |
| 1010 | 10 | — | 0 | 1 | |
| 1011 | 11 | — | 0 | 1 | |
| 1100 | 12 | — | 0 | 1 | |
| 1101 | 13 | NA | 1 | 0 | RV range |
| 1110 | 14 | | 2 | 0 | (retransmission |
| 1111 | 15 | | 3 | 0 | range) |

Essentially, Table 7 is similar to Table 6 (so is Table 8 to Table 3), except for adding another column to the reference table indicating the identified NDI setting for a respective signaled value. In general, independent from the specific example given in Table 7, it should be recognized that the definition of two ranges of values ("TF range" and "RV range") also defines two ranges of values indicating, whether new data is sent or whether a retransmission is provided. Essentially, selecting a value from the "TF range" indicates a new transmission, and is thus equivalent to a new data indicator being set (or a sequence number being incremented). Similarly, selecting a value from the "RV range" indicates no new data being transmitted and is thus equivalent to new data indicator not being set (or a sequence number not being incremented). As the setting of a new data indicator (incrementing the sequence number) typically coincides with the transmission of an initial transmission of a protocol data unit

or transport block respectively, for initial transmissions a value from the "TF range" should be signaled and for retransmissions, a value from the "RV range" should be signaled.

Another alternative approach to the joint encoding of transport format and redundancy version is the use of a shared field (which could be also referred to as a shared TF/RV field) in the control channel information format to be used for the signaling of transport format and redundancy version. In this alternative approach, according to another embodiment of the invention, it is assumed that the transport format is generally associated to a specific redundancy version for the initial transmission (or the redundancy version for the initial transmission is either fixed or pre-defined). Accordingly, in case of an initial transmission, the shared field is interpreted as signaling a transport format, as shown in Table 9, and so to say implicitly indicating a redundancy version of the respective transmission in a similar fashion as discussed in some examples above relating to the joint encoding approach.

Furthermore, it is also assumed, that the transport block size is not changing between initial transmission and retransmission of a protocol data unit or transport block. Hence, in case of a retransmission the shared field in the control channel signal is interpreted as a redundancy version, as shown in Table 10.

TABLE 9

| Signaled Value (binary) | Signaled Value (decimal) | TF (TBS) |
|---|---|---|
| 0000 | 0 | — |
| 0001 | 1 | — |
| 0010 | 2 | — |
| 0011 | 3 | — |
| 0100 | 4 | — |
| 0101 | 5 | 100 |
| 0110 | 6 | 120 |
| 0111 | 7 | 150 |
| 1000 | 8 | 200 |
| 1001 | 9 | — |
| 1010 | 10 | — |
| 1011 | 11 | — |
| 1100 | 12 | |
| 1101 | 13 | — |
| 1110 | 14 | — |
| 1111 | 15 | — |

TABLE 10

| Signaled Value (binary) | Signaled Value (decimal) | RV |
|---|---|---|
| 0000 | 0 | RV 0 |
| 0001 | 1 | RV 1 |
| 0010 | 2 | RV 2 |
| 0011 | 3 | RV 3 |
| 0100 | 4 | RV 4 |
| 0101 | 5 | — |
| 0110 | 6 | — |
| 0111 | 7 | — |
| 1000 | 8 | |
| 1001 | 9 | — |
| 1010 | 10 | — |
| 1011 | 11 | — |
| 1100 | 12 | — |
| 1101 | 13 | — |
| 1110 | 14 | reserved |
| 1111 | 15 | reserved |

Comparing the joint encoding approach and the use of a shared field, the main difference between the approaches is the interpretation of the bits of the respective fields. In the joint encoding case, the same reference table is used for interpreting the bits of the common field in the control channel signal to determine transport format and redundancy version of a transmission, irrespective of whether the transmission is an initial transmission or a retransmission. Furthermore, in case of additionally jointly encoding the sequence number or a new data indicator, the value range that can be represented by the bits in the common field should be separated into two ranges so as to be able to differentiate between initial transmission and retransmission and to thereby recognize a new data indicator being set or a sequence number being incremented. In contrast, the shared field approach is using two different reference tables for the interpretation of the bits contained in the common field for transport format and redundancy version (see Tables 9 and 10 above), depending on whether an initial transmission or a retransmission is sent. This allows more freedom and flexibility to indicate a larger variety of transport formats and redundancy versions or may allow reducing the size of the signaling field.

However, the receiver of the control channel signal must be aware of whether an initial transmission or a retransmission is associated to the respective control channel signal. In theory, the receiver of the control channel signal may derive the information from its own feedback, which is however not necessarily very reliable as the feedback may be lost or misinterpreted.

Therefore, in one further embodiment of the invention, it is suggested that the control channel signal further comprises an additional sequence number field or new data indicator. In case of using a new data indicator, the interpretation of the shared TF/RV field depends on the value of the new data indicator field, i.e. returning to the example above, the receiver (e.g. mobile station) of the control channel signal either chooses Table 9 or table 10 for interpreting the shared TF/RV field depending on the setting of the new data indicator. Similarly, in case of having a sequence number field, the receiver selects the reference table for interpreting the content of the shared TF/RV field based on the sequence number being incremented or not.

The differences between a joint encoding of transport format and redundancy version in a common field and the use of a shared field will be exemplified with respect to FIG. 5 and FIG. 6. In FIG. 5 a control channel signal according to one exemplary embodiment is shown. The control channel signal comprises a resource allocation field (RB allocation), a TF/RV field for jointly encoding transport format and redundancy version ("Joint TF/RV field"), a NDI/SN field and HARQ process field. The same configuration of the control channel signal is provided on FIG. 6.

In FIG. 5, the transport format and redundancy version are jointly encoded in a common field ("Joint TF/RV field") irrespective of whether the control channel information relate to an initial transmission or a retransmission. The four bits of the common field for transport format and redundancy version may for example represent the transport format and redundancy versions as outlined above with respect to Tables 3 to 6.

In FIG. 6, the shared field approach according to one exemplary embodiment of the invention is illustrated in further detail. The NDI/SN field may either comprise a new data indicator or a sequence number and is used to determine, whether the control channel information relates to an initial transmission and which reference information are to be used for interpreting the content of the shared TF/RV field. If the control channel information is related to an initial transmis-

sion of a protocol data unit or transport block, the shared TF/RV field indicates the transport format thereof, as for example shown in Table 9 above. If the control channel information is related to a retransmission, the shared TF/RV field indicates the redundancy version of the protocol data unit, as for example shown in Table 10 above.

Next, operation of the transmitter of the control channel signal according to one of the various embodiments described herein and the receiver thereof will be described in further detail, thereby exemplarily relating to the case of downlink data transmission. For exemplary purposes a network as exemplified in FIG. 10 may be assumed. The mobile communication system of FIG. 10 is considered to have a "two node architecture" consisting of at least one Access and Core Gateway (ACGW) and Node Bs. The ACGW may handle core network functions, such as routing calls and data connections to external networks, and it may also implement some RAN functions. Thus, the ACGW may be considered as to combine functions performed by GGSN and SGSN in today's 3G networks and RAN functions as for example radio resource control (RRC), header compression, ciphering/integrity protection.

The base stations (also referred to as Node Bs or enhanced Node Bs=eNode Bs) may handle functions as for example segmentation/concatenation, scheduling and allocation of resources, multiplexing and physical layer functions, but also RRC functions, such as outer ARQ. For exemplary purposes only, the eNodeBs are illustrated to control only one radio cell. Obviously, using beam-forming antennas and/or other techniques the eNodeBs may also control several radio cells or logical radio cells.

In this exemplary network architecture, a shared data channel may be used for communication of user data (in form or protocol data units) on uplink and/or downlink on the air interface between mobile stations (UEs) and base stations (eNodeBs). This shared channel may be for example a Physical Uplink or Downlink Shared CHannel (PUSCH or PDSCH) as know in LTE systems. However, it is also possible that the shared data channel and the associated control channels are mapped to the physical layer resources as shown in FIG. 2 or FIG. 3.

The control channel signals/information may be transmitted on separate (physical) control channels that are mapped into the same subframe to which the associated user data (protocol data units) are mapped or may be alternatively sent in a subframe preceding the one containing the associated information. In one example, the mobile communication system is a 3GPP LTE system, and the control channel signal is L1/L2 control channel information (e.g. information on the Physical Downlink Control CHannel—PDCCH). Respective L1/L2 control channel information for the different users (or groups of users) may be mapped into a specific part of the shared uplink or downlink channel, as exemplarily shown in FIGS. 2 and 3, where the control channel information of the different users is mapped to the first part of a downlink subframe ("control").

FIG. 8 shows a message exchange and tasks performed by a transmitted and a receiver of a control channel signal according to an exemplary embodiment of the invention. The message exchange may be performed in the mobile communication network shown in FIG. 10. Accordingly, as the example in FIG. 8 is relating to the downlink data transmission, the transmitter shown in FIG. 8 may be assumed to correspond to base station/Node B NB1 in FIG. 10 and the receiver shown in FIG. 8 may be assumed to correspond to mobile station/UE MS1 in FIG. 10. Generally, it may be assumed in FIG. 8 that a retransmission protocol, such as Hybrid ARQ, is used between the transmitter (here: base station NB1) and receiver (here: mobile station MS1) of the data (protocol data unit) so as to ensure successful decoding of the data at the receiver.

Mobile station MS1 is first receiving 801 the PDCCH and obtains a L1/L2 control channel signal. Subsequently, the mobile station MS1 interprets (or decodes) 802 the content of L1/L2 control channel signal. The control channel signal may be assumed to have a format as exemplified in FIG. 6. Next, the mobile station MS1 receives and tries to decode 804 the protocol data unit transmitted 803 on the associated downlink data channel with the parameters indicated by the L1/L2 control channel signal.

In case the mobile station MS1 can decode the protocol data unit successfully (known due to correct CRC), it transmits an ACK on the uplink. Alternatively, the mobile transmits 805 an NACK on the uplink, if it has not decoded the data correctly (known due to false CRC). In case mobile station MS1 did not receive (decode correctly) the control channel signal from the PDCCH, it does not transmit an ACK or NACK on the uplink (DTX).

In case of receiving a NACK at the base station NB1, same will provide a retransmission of the protocol data unit to the mobile station. As the retransmission of the protocol data unit is exemplarily assumed to be another redundancy version of the same protocol data unit, the base station NB1 generates 806 a control channel signal for the retransmission and transmits 807, this control channel signal and the retransmission of the protocol data unit 809 to mobile station MS1. Similar to steps 802 and 804, mobile station MS1 receives 808 the control channel signal for the retransmission and uses the parameters indicated therein to receive and decode 810 the retransmission of the protocol data unit. As it is assumed that the protocol data unit may be correctly decoded after having received the retransmission, mobile station MS1 informs 811 the base station NB1 on the successful (unsuccessful) decoding by means of an ACK (NACK).

In a further embodiment, some further improvement to the retransmission protocol is suggested. This improvement will be outlined with the exemplary signaling flow and data exchange as illustrated in FIG. 9. It may be assumed that the retransmission protocol is provided on the Medium Access Layer (MAC) of the mobile communication system and that another higher layer protocol in the protocol stack provides another retransmission function to ensure successful data delivery. For example, this higher layer protocol may be the Radio Link Control (RLC) protocol.

Generally, if a mobile station misses 901 the control signaling (e.g. on the PDCCH) for the initial transmission of a protocol data unit (e.g. MAC PDU), it may also not receive 903 the initial transmission of the protocol data unit as well. Furthermore, the mobile station is also not aware of the transport format that will be used for the transmission and retransmissions of the protocol data unit and provides no feedback to the transmitting base station.

In case the base station does not receive any feedback for the initial transmission, a typical implementation of the scheduler unit of the base station considers 903 this absence of feedback as a NACK (two-state ACK/NACK receiver) and the base station generates 904 and transmits 905, another L1/L2 control signaling for the retransmission of the protocol data unit.

If the mobile station subsequently receives 906 this L1/L2 control signaling for the retransmission. Assuming now that there is a common field for the transport format and the redundancy version within the control signaling, the bits in the common TF/RV field do not yield the transport format

(e.g. transport block sizes, MCS, etc.) of the protocol data unit, but may only indicate the redundancy version (see for example Tables 3 to 8 and assuming that a value of the "RV range" is signaled for retransmission or see Table 9 for the shared TF/RV field approach). Even though the mobile station is not capable of receiving the retransmission **907** of the protocol data unit, according to this embodiment of the invention, the mobile station sends **908** a positive acknowledgement (ACK) in order to abort the transmission of the current protocol data unit (MAC PDU), since otherwise (transmitting NACK) the base station would continue with retransmissions without the mobile terminal having a chance to correctly decode the transport block. The transmission of an ACK causes the transport block being lost, however retransmission of this transport block (protocol data unit) can be taken care of by higher layer (ARQ) protocols, if available (e.g. RLC).

A similar behavior can for example also be implemented in case the base station (or rather the scheduling unit) has the capability to not only detect ACK/NACKs from but also a transmitted DTX (i.e. no transmission of ACK/NACK)—i.e. a three-state ACK/NACK/DTX receiver—for situations where the mobile station missed the control signaling on the PDCCH, but due to an error in receiving/decoding the feedback—the base station wrongly detects a NACK instead of DTX. In this case the base station will send a retransmission for the protocol data packet together with an associated control channel signal indicating the transmission to be a retransmission, similar as for the 2-state ACK/NACK receiver case described above. In this case, the mobile station may detect a protocol error and sends a positive acknowledgement to abort the retransmissions. In case the base station correctly detects the DTX signal, the base station may transmit another initial transmission (indicating the transport format) of the same transport block or of a newly constructed transport block.

The exemplary embodiments discussed above have been mainly focused on L1/L2 control signaling for downlink data transmission. Also in case of uplink data transmissions, the L1/L2 control signaling may be transmitted in the downlink. As the transmission of the (user) data is on another link (uplink), the transmissions of the data may take place on different sub-frames numbers than the associated control signaling (because uplink and downlink may not really be synchronized, i.e. the timing of the uplink and downlink sub-frames are different). In any case there needs to be a well-defined mapping of the sub-frame the control signaling takes place and the sub-frame the actual data transmission takes place. Accordingly in TDD systems, the subframes may be different for uplink and for downlink.

In the following further options and improvements to the L1/L2 control signaling discussed previously herein will be discussed.

Another embodiment of the invention relates to a further improvement of the use of a shared TF/RV field in the control channel signal. The number of signaling bits for the transport format (e.g. 4-7 bits) is typically larger than the bits needed for the redundancy (e.g. 1-3 bits). Therefore, in case of signaling the redundancy version for retransmissions some bits (or values) of the shared TF/RV field may for example be used to transmit other useful control information. For example, some or all bits not used for signaling the redundancy version may be used to signal:

- the modulation scheme as shown in FIG. **11**, e.g. in case the modulation scheme should be controlled for each retransmission independently. In this case the code rate for decoding can be determined from the transport block size known from a previous transmission (typically initial transmission), the signaled resource allocation (from which the resource allocation size can be determined) and the signaled modulation scheme.
- additional restricted transport format related information, e.g. on modulation only, on the MCS level, on the TBS, etc.
- MIMO HARQ sub-process information, as for example suggested in 3GPP TSG RAN WG1 #47 Tdoc. R1-063548, "MIMO HS-SCCH structure", November 2006 (available at http://www.3gpp.org and incorporated herein by reference). Assuming a MIMO mode supporting a 2 code word transmission and 2 HARQ processes, typically, the sub process number needs to be signaled in the L1/L2 control channel, which requires an additional bit for the HARQ process. Assuming that this bit is not required in initial transmissions, in retransmissions this bit can be signaled on the available space.
- additional power control information for uplink/downlink control and data channels.
- information on the resources used (by the base station) or to be used (by the UE) for the ACK/NACK signaling. This information maybe e.g. an explicit indication of the resources or maybe restricting the resources.
- a flag bit indicating that the remaining bits in the shared field are used for RV information or e.g. for (restricted) TF information (see FIG. 7). This maybe especially beneficial in case of self-decodable retransmissions, where the base station has the flexibility to choose what to signal in the retransmissions.

It should be noted, that in a further embodiment of the invention, control channel signaling is transmitted for initial transmissions and optionally in addition for selected retransmissions of a protocol data unit. Thus, some or all retransmissions may be transmitted without a control channel. In this case the control information for being able to receive the transmission of the associated protocol data unit may be derived from the control signaling for the initial transmission of the protocol data unit, from an earlier (re)transmission of the protocol data unit or the transport format and redundancy version for the retransmissions may be predefined. E.g. the resource allocation may be derived from the resource allocation of an earlier transmission (e.g. identical resource allocation or predefined hopping and resizing of the resource allocation). This implementation may be for example used for uplink data transmission with a synchronous HARQ protocol.

In comparison to conventional schemes the use of a common field for transport format and redundancy version (and optionally the NDI/SN) has the following advantages. The reduction of the L1/L2 control signaling overhead compared to having separate field in the control channel format for transport format, redundancy version and NDI/SN fields by the disclosed concept is up to 3 bits depending on the actual embodiment. Assuming L1/L2 control signaling formats as described in the co-pending PCT application no. PCT/EP2007/010755, "Configuration of Control Channels in a Mobile Communication System" (by the same applicant, filed Dec. 10, 2007) yielding sizes between ~25 and ~80 bits for the L1/L2 control channel signal, this results into an overhead reduction of 4-12%. Especially, for the small L1/L2 control signaling formats the reduction is beneficial (up to 12% reduction), since these are used for cell-edge mobile stations, where the (power and time-frequency) resources per L1/L2 control channel (PDCCH) are large due to power and MCS control of the L1/L2 control channel (PDCCH). Therefore, the concept of having a common field for encoding transport format and redundancy version (and optionally the NDI/SN) allows for an increased coverage and cell size.

Furthermore, the use of a common field for encoding transport format and redundancy version (and optionally the NDI/SN) in the control signaling also allows signaling more transport format sizes. Assuming that e.g. in total 8 bits for transport format, redundancy version and NDI/SN (5 bits TF, 2 bits RV, 1 bit NDI/SN) are used in a conventional system to code the respective fields individually, the joint encoding of transport format and redundancy version and still having a separate NDI/SN field allows using 7 bits for a common field. The prior art yields up to $2^5-1=31$ transport format values (one value reserved for "Out of Range"), whereas the joint encoding of transport format and redundancy version in a TF/RC field yields $2^7-3=125$ transport format values (assuming 3 values are to be reserved for signaling 3 RVs defined for retransmissions). This provides a significantly finer granularity of transport block sizes allowing e.g. for a lower MAC PDU padding overhead or a finer link adaptation by MCS selection. In case of additionally jointly encoding the NDI, the number of transport formats values further increases to $2^8-3=253$.

Furthermore, as discussed in several examples above, in implementations where the transport format (Transport Block Size) does not change for retransmissions, which should be the case, since otherwise soft-combining is not feasible, no transport format needs to be signaled for retransmissions. In a conventional design, the transport format is also signaled in retransmissions. In certain cases, the signaling of the transport format for retransmissions can help from recovering error cases (e.g. if the receiver missed the transmission of the control signaling for the initial transmission). However, these error cases are very unlikely for certain systems, and therefore, it is more efficient to avoid signaling of the transport format for retransmissions, which saves control signaling overhead.

The signaling of the transport format for retransmission typically causes additional overhead in the control signaling so as to account for error cases in case the resource allocation size is changing for retransmissions. In certain cases, it can happen that the transport format (transport blocks size), which needs to be signaled for retransmissions in conventional designs, is not within the range of the values that can be signaled after the update of the resource allocation. In this case, conventional systems typically define an "Out of Range" value to account for these situations. In some of the embodiments of the invention discussed herein, this "Out of Range" value is not required since the transport format (transport block size) is not signaled in retransmissions.

Another feature of the invention according to some embodiments of the invention is that it does not allow for a dynamic selection of the redundancy version for the initial transmission. This is not necessarily a drawback in comparison with conventional solutions (which may allow for a free choice of the redundancy version for initial transmissions), since dynamic redundancy version selection is typically not beneficial and may only be applied in rare cases.

Examples of mobile communication systems in which the principles of the invention outlined herein may be utilized are communication systems utilizing an OFDM scheme, a MC-CDMA scheme or an OFDM scheme with pulse shaping (OFDM/OQAM).

Another embodiment of the invention relates to the implementation of the above described various embodiments using hardware and software. It is recognized that the various embodiments of the invention may be implemented or performed using computing devices (processors). A computing device or processor may for example be general purpose processors, digital signal processors (DSP), application specific integrated circuits (ASIC), field programmable gate arrays (FPGA) or other programmable logic devices, etc. The various embodiments of the invention may also be performed or embodied by a combination of these devices.

Further, the various embodiments of the invention may also be implemented by means of software modules, which are executed by a processor or directly in hardware. Also a combination of software modules and a hardware implementation may be possible. The software modules may be stored on any kind of computer readable storage media, for example RAM, EPROM, EEPROM, flash memory, registers, hard disks, CD-ROM, DVD, etc.

Furthermore, it should be noted that the terms mobile terminal and mobile station are used as synonyms herein. A user equipment may be considered one example for a mobile station and refers to a mobile terminal for use in 3GPP-based networks, such as LTE.

In the previous paragraphs various embodiments of the invention and variations thereof have been described. It would be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described.

It should be further noted that most of the embodiments have been outlined in relation to a 3GPP-based communication system and the terminology used in the previous sections mainly relates to the 3GPP terminology. However, the terminology and the description of the various embodiments with respect to 3GPP-based architectures is not intended to limit the principles and ideas of the inventions to such systems.

Also the detailed explanations given in the Technical Background section above are intended to better understand the mostly 3GPP specific exemplary embodiments described herein and should not be understood as limiting the invention to the described specific implementations of processes and functions in the mobile communication network. Nevertheless, the improvements proposed herein may be readily applied in the architectures described in the Technical Background section. Furthermore, the concept of the invention may be also readily used in the LTE RAN currently discussed by the 3GPP.

The invention claimed is:

1. A mobile terminal for use in a mobile communication system, the mobile terminal comprising:
- a receiver unit for receiving a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal,
- a processing unit for determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data, and
- a transmitter unit for transmitting the protocol data unit on at least one physical radio resource using the transport format and the redundancy version of the protocol data unit indicated in the received control channel signal,
- wherein the control channel signal received within said sub-frame comprises a control information field, in which the transport format and the redundancy version of the protocol data unit are jointly encoded,
- wherein the processing unit is further configured for the determination of the control information field, which consists of a number of bits representing a range of values that can be represented in the control information field, wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first

subset of the values, is reserved for indicating the redundancy version for transmitting the user data, and

wherein the first subset of the values contains more values than the second subset of the values.

2. The mobile terminal according to claim 1, wherein every value of the first subset of the values indicates a transport format and every value of the second subset of the values indicates a redundancy version.

3. The mobile terminal according to claim 1, wherein the redundancy version of the protocol data unit is implicit in the transport format indicated by a corresponding value of the first subset.

4. The mobile terminal according to claim 1, wherein the value of the encoded information bits in the control information field is representing a value of the first subset of the values, in case the transmission of the protocol data unit is an initial transmission of the user data.

5. The mobile terminal according to claim 1, wherein the value of the encoded information bits in the control information field is representing a value of the first subset or the second subset of the values, in case the transmission of the protocol data unit is a retransmission of the user data.

6. The mobile terminal according to claim 1, wherein the value of the encoded information bits in the control information field is representing a value of the second subset of the values, in case the transmission of the protocol data unit is a retransmission of the user data.

7. The mobile terminal according to claim 1, wherein the bits of the control information field jointly encode the transport format, the redundancy version used for transmitting the protocol data unit, and a new data indicator for indicating whether the transmission of the protocol data unit is an initial transmission of the user data, and

wherein use of one of the values of the first subset also indicates the transmission of the protocol data unit to be an initial transmission.

8. The mobile terminal according to claim 1, wherein the redundancy version to be used for the initial transmission of the user data in the protocol data unit is fixed or preconfigured.

9. The mobile terminal according to claim 1, wherein the control channel signal is further comprising a sequence number field indicating a sequence number of the protocol data unit.

10. The mobile terminal according to claim 1, wherein the control channel signal is further comprising a new data indicator field indicating whether the transmission of the protocol data unit is an initial transmission or a retransmission of the user data.

11. The mobile terminal according to claim 1, wherein the control channel signal further comprises a mobile terminal identifier field for indicating the mobile terminal or a group of mobile terminals that are to receive the control channel signal.

12. The mobile terminal according to claim 1, wherein the control channel signal is a L1/L2 control channel signal.

13. The mobile terminal according to claim 1, wherein in case the transmission of the protocol data unit is a retransmission of the user data, the bits of the control information field include a flag indicating a type of information indicated by the remaining bits of the control information field.

14. A method for use in a mobile communication system, the method comprising the following steps performed by a mobile terminal:

receiving a sub-frame of physical radio resources comprising a control channel signal destined to the mobile terminal,

determining based on the received control channel signal a transport format of and a redundancy version for an initial transmission or a retransmission a protocol data unit conveying user data, and

transmitting the protocol data unit on at least one physical radio resource using the transport format and the redundancy version of the protocol data unit indicated in the received control channel signal,

wherein the control channel signal received within said sub-frame comprises a control information field, in which the transport format and the redundancy version of the protocol data unit are jointly encoded,

wherein the control information field consists of a number of bits representing a range of values that can be represented in the control information field, wherein a first subset of the values is reserved for indicating the transport format of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version for transmitting the user data, and

wherein the first subset of the values contains more values than the second subset of the values.

15. The method according to claim 14, wherein every value of the first subset of the values indicates a transport format and every value of the second subset of the values indicates a redundancy version.

16. The method according to claim 14, wherein the redundancy version of the protocol data unit is implicit in the transport format indicated by a corresponding value of the first subset.

17. The method according to claim 14, wherein the value of the encoded information bits in the control information field is representing a value of the first subset of the values, in case the transmission of the protocol data unit is an initial transmission of the user data.

18. The method according to claim 14, wherein the value of the encoded information bits in the control information field is representing a value of the first subset or the second subset of the values, in case the transmission of the protocol data unit is a retransmission of the user data.

19. The method according to claim 14, wherein the value of the encoded information bits in the control information field is representing a value of the second subset of the values, in case the transmission of the protocol data unit is a retransmission of the user data.

20. The method according to claim 14, wherein the bits of the control information field jointly encode the transport format, the redundancy version used for transmitting the protocol data unit, and a new data indicator for indicating whether the transmission of the protocol data unit is an initial transmission of the user data, and

wherein use of one of the values of the first subset also indicates the transmission of the protocol data unit to be an initial transmission.

21. The method according to claim 14, wherein the redundancy version to be used for the initial transmission of the user data in the protocol data unit is fixed or preconfigured.

22. The method according to claim 14, wherein the control channel signal is further comprising a sequence number field indicating a sequence number of the protocol data unit.

23. The method according to claim 14, wherein the control channel signal is further comprising a new data indicator field indicating whether the transmission of the protocol data unit is an initial transmission or a retransmission of the user data.

24. The method according to claim 14, wherein the control channel signal further comprises a mobile terminal identifier

field for indicating the mobile terminal or a group of mobile terminals that are to receive the control channel signal.

**25**. The method according to claim **14**, wherein the control channel signal is a L1/L2 control channel signal.

**26**. The method according to claim **14**, wherein in case the transmission of the protocol data unit is a retransmission of the user data, the bits of the control information field include a flag indicating a type of information indicated by the remaining bits of the control information field.

**27**. The method according to claim **14**, wherein the transport format is transport block size information of the protocol data unit, and wherein the received control channel signal further comprises a resource allocation field indicating the physical radio resource or resources allocated to the mobile terminal,

and said determining depends on the information comprised in the resource allocation field and the control information field.

**28**. The method according to claim **14**, further comprising reusing the transport format of the protocol data unit indicated in the control channel signal for the initial transmission, for the retransmission of the protocol data unit.

**29**. The method according to claim **14**, wherein the bits of the control information field are associated with single reference information indicating a transport format and a redundancy version used for transmitting the protocol data unit, the single reference information being associated with respective values represented by the bits of the control information field for an initial transmission and a retransmission of the protocol data unit.

**30**. A base station for use in a mobile communication system, the base station comprising:

a transmitter unit for transmitting a sub-frame of physical radio resources comprising a control channel signal to a mobile terminal, the control channel signal indicating a transport format of and a redundancy version for an initial transmission or a retransmission of a protocol data unit conveying user data for use in an uplink transmission from the mobile terminal, and

a receiver unit for receiving the uplink transmission of the protocol data unit from the mobile terminal on at least one physical radio resource using the transport format and the redundancy version indicated in the control channel signal,

wherein the control channel signal transmitted within said sub-frame comprises a control information field, in which the transport format and the redundancy version of the protocol data unit are jointly encoded,

wherein the control information field consists of a number of bits representing a range of values that can be represented in the control information field, wherein a first subset of the values is reserved for indicating the transport format used for the uplink transmission of the protocol data unit and a second subset of the values, different from the first subset of the values, is reserved for indicating the redundancy version used for the uplink transmission of the protocol data unit, and

wherein the first subset of the values contains more values than the second subset of the values.

**31**. The base station according to claim **30**, wherein every value of the first subset of the values indicates a transport format and every value of the second subset of the values indicates a redundancy version.

**32**. The base station according to claim **30**, wherein the redundancy version for the uplink transmission of the protocol data unit is implicit in the transport format indicated by a corresponding value of the first subset.

**33**. The base station according to claim **30**, wherein the value of the encoded information bits in the control information field is representing a value of the first subset of the values, in case the transmission of the protocol data unit is an initial transmission of the user data.

**34**. The base station according to claim **30**, wherein the value of the encoded information bits in the control information field is representing a value of the first subset or the second subset of the values, in case the transmission of the protocol data unit is a retransmission of the user data.

**35**. The base station according to claim **30**, wherein the value of the encoded information bits in the control information field is representing a value of the second subset of the values, in case the transmission of the protocol data unit is a retransmission of the user data.

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**April 18, 2019**

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**U.S. PATENT:** ***8,411,557***
**ISSUE DATE:** ***April 02, 2013***

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**Certifying Officer**

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2:19-cv-00066-JRG

US008411557B2

(12) **United States Patent**
**Imamura et al.**

(10) **Patent No.: US 8,411,557 B2**
(45) **Date of Patent: *Apr. 2, 2013**

(54) **MOBILE STATION APPARATUS AND RANDOM ACCESS METHOD**


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(73) Assignee: **Panasonic Corporation**, Osaka (JP)



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This patent is subject to a terminal disclaimer.

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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***H04J 11/00*** (2006.01)
***H04B 7/216*** (2006.01)

(52) **U.S. Cl.** ........................ **370/208**; 370/335; 370/342

(58) **Field of Classification Search** ................. 370/208, 370/335, 342, 441

See application file for complete search history.


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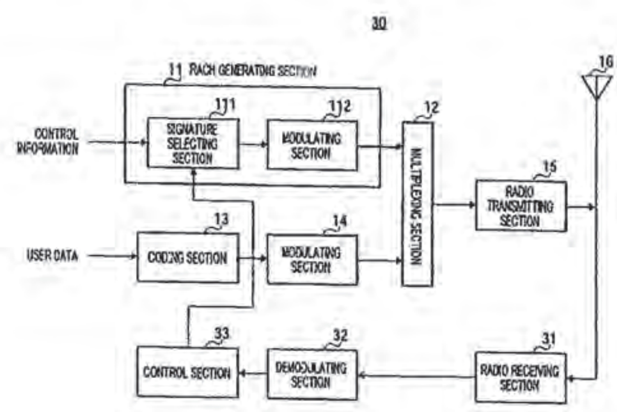
(57) **ABSTRACT**


A mobile station apparatus includes a receiving unit configured to receive control information; a selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities; and a transmitting unit for transmitting the selected sequence. The predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts. A position at which the predetermined number of sequences are partitioned is determined based on the control information, and a number of sequences contained in each of the plurality of groups varies in accordance with the control information.


**10 Claims, 11 Drawing Sheets**



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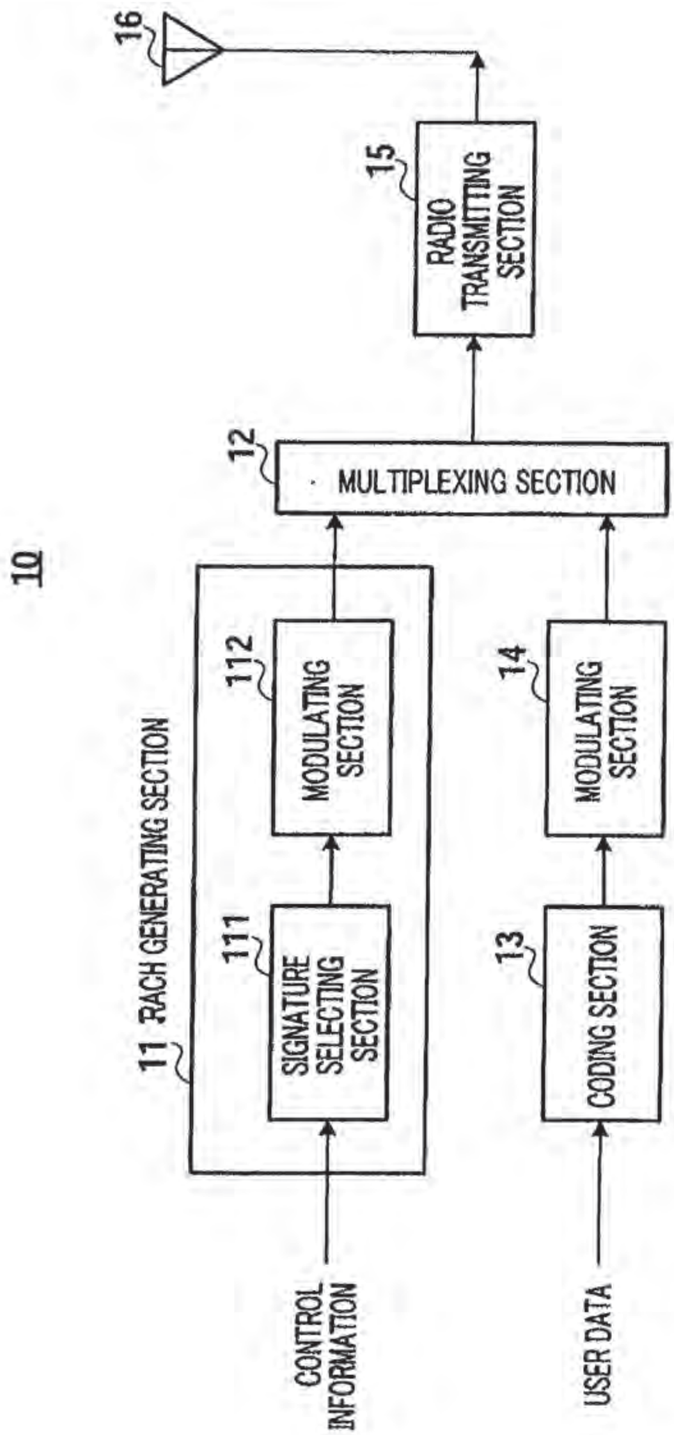
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16
15
RADIO TRANSMITTING SECTION
12
MULTIPLEXING SECTION
11 RACH GENERATING SECTION
111
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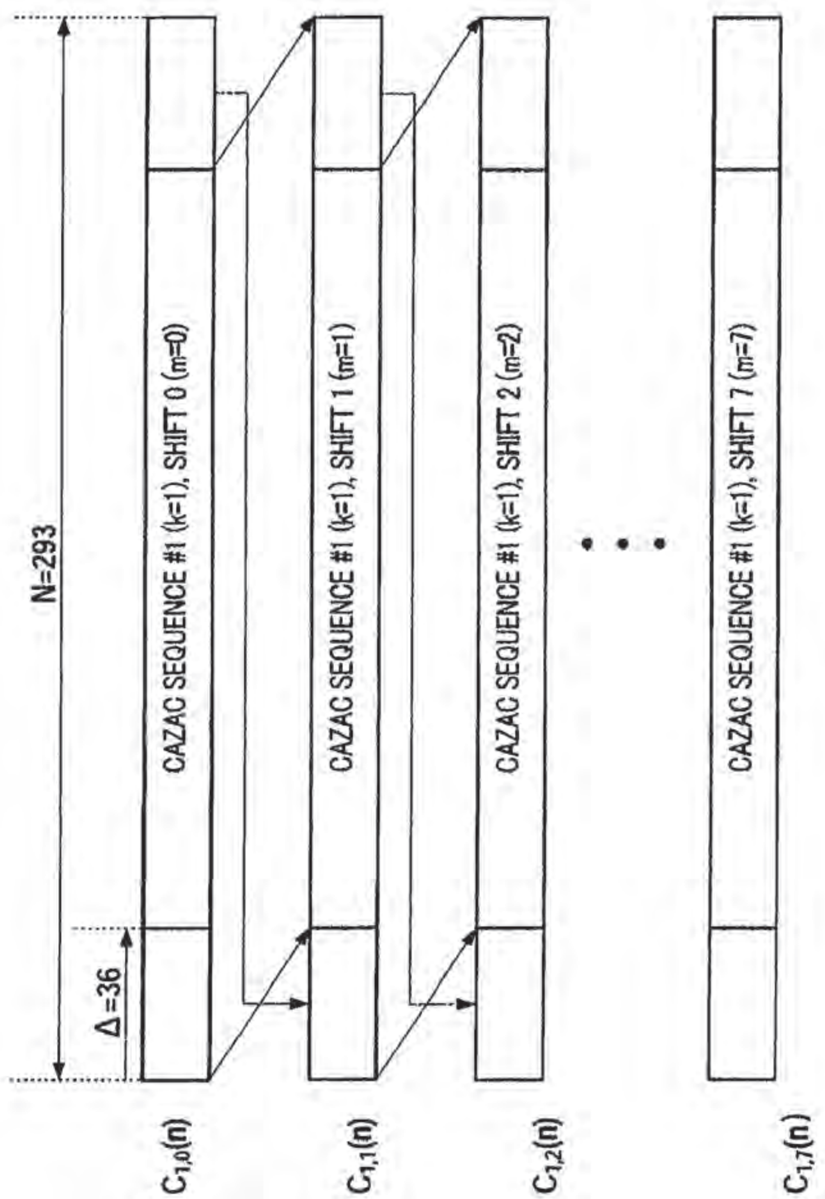
MODULATING SECTION
13
CODING SECTION
14
MODULATING SECTION
CONTROL INFORMATION
USER DATA

FIG.1



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CAZAC SEQUENCE #1 (k=1), SHIFT 0 (m=0)
CAZAC SEQUENCE #1 (k=1), SHIFT 1 (m=1)
CAZAC SEQUENCE #1 (k=1), SHIFT 2 (m=2)
CAZAC SEQUENCE #1 (k=1), SHIFT 7 (m=7)
$C_{1,0}(n)$
$C_{1,1}(n)$
$C_{1,2}(n)$
$C_{1,7}(n)$


FIG.2

| RECEIVED QUALITY | CONTROL INFORMATION |
|---|---|
| SINR < −5dB | 000 |
| −5dB ≦ SINR < 0dB | 001 |
| 0dB ≦ SINR < 5dB | 010 |
| 5dB ≦ SINR < 10dB | 011 |
| 10dB ≦ SINR < 15dB | 100 |
| 15dB ≦ SINR < 20dB | 101 |
| 20dB ≦ SINR < 25dB | 110 |
| 25dB ≦ SINR | 111 |

FIG.3

| CONTROL INFORMATION | CAZAC SEQUENCE NUMBER: k | SHIFT: m | SIGNATURE NUMBER |
|---|---|---|---|
| 000 | #1 | 0 | #1 |
| | | 1 | #2 |
| | | ⋮ | ⋮ |
| | | 7 | #8 |
| 001 | #2 | 0 | #9 |
| | | 1 | #10 |
| | | ⋮ | ⋮ |
| | | 7 | #16 |
| 010 | #3 | 0 | #17 |
| | | 1 | #18 |
| | | ⋮ | ⋮ |
| | | 7 | #24 |
| 011 | #4 | 0 | #25 |
| | | 1 | #26 |
| | | ⋮ | ⋮ |
| | | 7 | #32 |
| 100 | #5 | 0 | #33 |
| | | 1 | #34 |
| | | ⋮ | ⋮ |
| | | 7 | #40 |
| 101 | #6 | 0 | #41 |
| | | 1 | #42 |
| | | ⋮ | ⋮ |
| | | 7 | #48 |
| 110 | #7 | 0 | #49 |
| | | 1 | #50 |
| | | ⋮ | ⋮ |
| | | 7 | #56 |
| 111 | #8 | 0 | #57 |
| | | 1 | #58 |
| | | ⋮ | ⋮ |
| | | 7 | #64 |

TABLE

FIG.4

| CONTROL INFORMATION | CAZAC SEQUENCE NUMBER: k | SHIFT: m |
|---|---|---|
| 000 | #1 | 0~7 |
| 001 | #2 | 0~7 |
| 010 | #3 | 0~7 |
| 011 | #4 | 0~7 |
| 100 | #5 | 0~7 |
| 101 | #6 | 0~7 |
| 110 | #7 | 0~7 |
| 111 | #8 | 0~7 |

TABLE

FIG.5

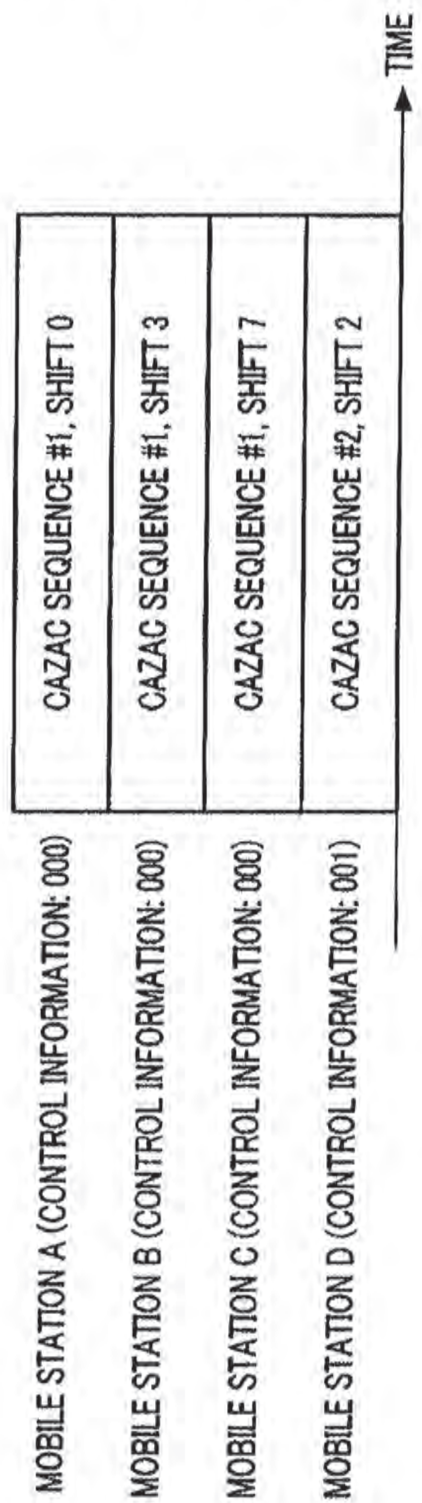
TIME
MOBILE STATION A (CONTROL INFORMATION: 000)
CAZAC SEQUENCE #1, SHIFT 0
MOBILE STATION B (CONTROL INFORMATION: 000)
CAZAC SEQUENCE #1, SHIFT 3
MOBILE STATION C (CONTROL INFORMATION: 000)
CAZAC SEQUENCE #1, SHIFT 7
MOBILE STATION D (CONTROL INFORMATION: 001)
CAZAC SEQUENCE #2, SHIFT 2

FIG.6

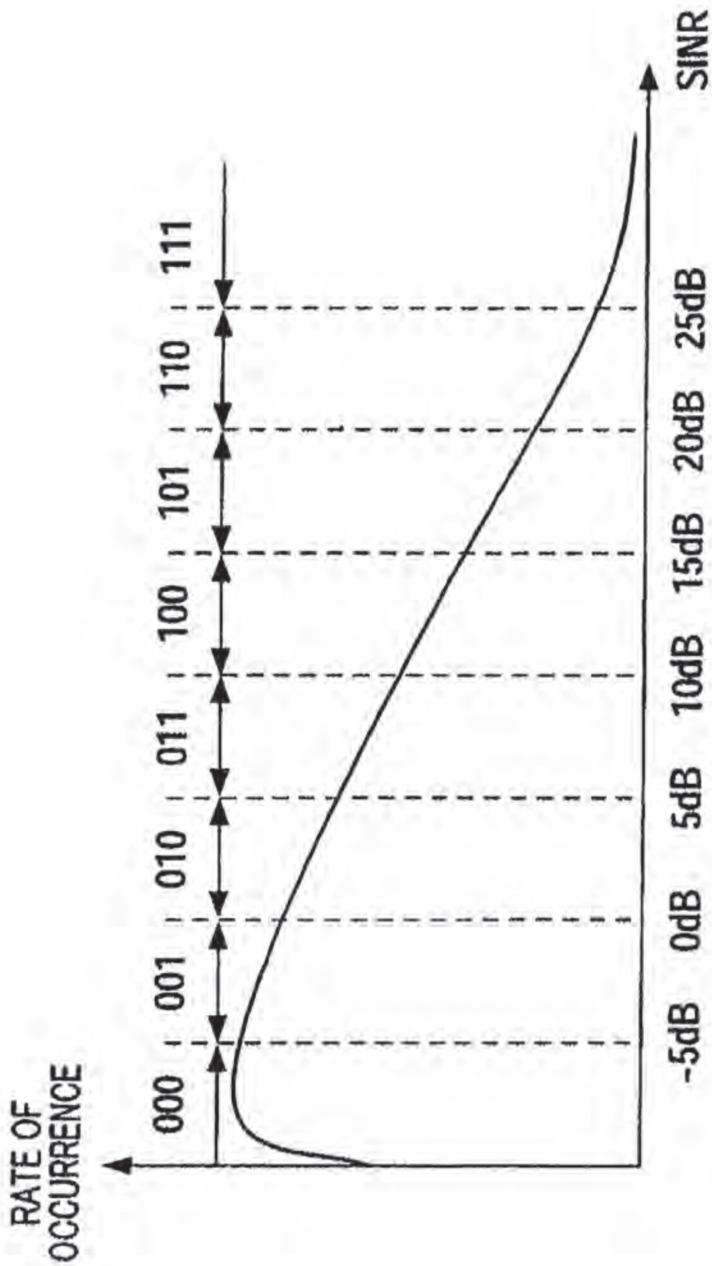
RATE OF OCCURRENCE
000
001
010
011
100
101
110
111
-5dB
0dB
5dB
10dB
15dB
20dB
25dB
SINR

FIG.7

| CONTROL INFORMATION | CAZAC SEQUENCE NUMBER: k | SHIFT: m |
|---|---|---|
| 000 | #1 | 0~ 7 |
| 001 | | 8~15 |
| 010 | | 16~23 |
| 011 | | 24~31 |
| 100 | #2 | 0~ 7 |
| 101 | | 8~15 |
| 110 | | 16~23 |
| 111 | | 24~31 |

TABLE

FIG.8

| CONTROL INFORMATION | CAZAC SEQUENCE NUMBER: k | SHIFT: m | SIGNATURE NUMBER |
|---|---|---|---|
| 000 | #1 | 0 | #1 |
| | | 1 | #2 |
| | | 2 | #3 |
| | | 3 | #4 |
| | | 4 | #5 |
| | | 5 | #6 |
| | | 6 | #7 |
| | | 7 | #8 |
| | #2 | 0 | #9 |
| | | 1 | #10 |
| | | 2 | #11 |
| | | 3 | #12 |
| | | 4 | #13 |
| | | 5 | #14 |
| 001 | | 6 | #15 |
| | | 7 | #16 |
| | #3 | 0 | #17 |
| | | 1 | #18 |
| | | 2 | #19 |
| | | 3 | #20 |
| | | 4 | #21 |
| | | 5 | #22 |
| | | 6 | #23 |
| | | 7 | #24 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| | #8 | 0 | #57 |
| 101 | | 1 | #58 |
| | | 2 | #59 |
| | | 3 | #60 |
| | | 4 | #61 |
| 111 | | 5 | #62 |
| | | 6 | #63 |
| | | 7 | #64 |

TABLE

FIG.9

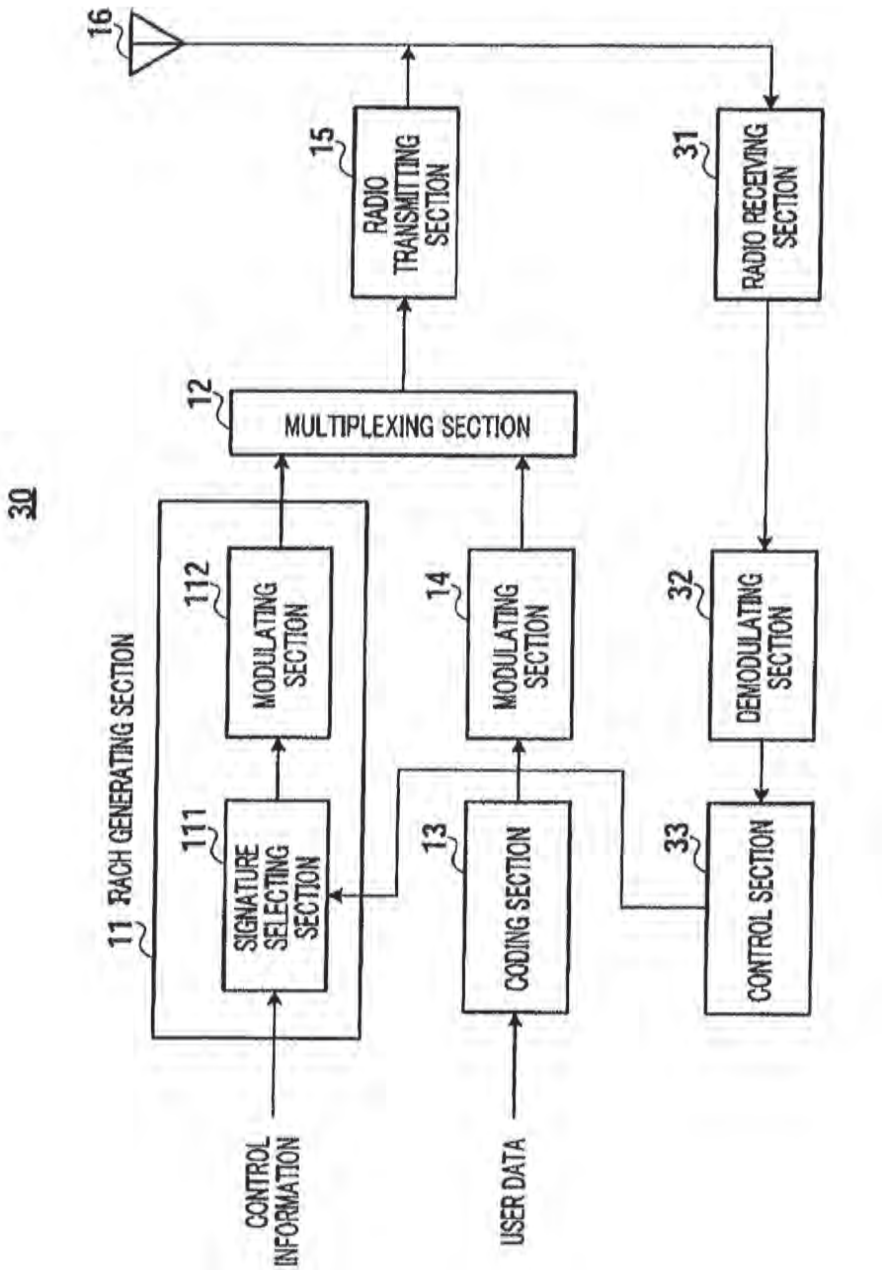
30
16
15
RADIO TRANSMITTING SECTION
31
RADIO RECEIVING SECTION
12
MULTIPLEXING SECTION
11 RACH GENERATING SECTION
112
MODULATING SECTION
111
SIGNATURE SELECTING SECTION
14
MODULATING SECTION
13
CODING SECTION
32
DEMODULATING SECTION
33
CONTROL SECTION
CONTROL INFORMATION
USER DATA

FIG.10

<table>
<tr><th>CONTROL INFORMATION</th><th>CAZAC SEQUENCE NUMBER: k</th><th>SHIFT: m</th><th>SIGNATURE NUMBER</th></tr>
<tr><td rowspan="16">000</td><td rowspan="8">#1</td><td>0</td><td>#1</td></tr>
<tr><td>1</td><td>#2</td></tr>
<tr><td>2</td><td>#3</td></tr>
<tr><td>3</td><td>#4</td></tr>
<tr><td>4</td><td>#5</td></tr>
<tr><td>5</td><td>#6</td></tr>
<tr><td>6</td><td>#7</td></tr>
<tr><td>7</td><td>#8</td></tr>
<tr><td rowspan="8">#2</td><td>0</td><td>#9</td></tr>
<tr><td>1</td><td>#10</td></tr>
<tr><td>2</td><td>#11</td></tr>
<tr><td>3</td><td>#12</td></tr>
<tr><td>4</td><td>#13</td></tr>
<tr><td>5</td><td>#14</td></tr>
<tr><td>6</td><td>#15</td></tr>
<tr><td>7</td><td>#16</td></tr>
<tr><td rowspan="6">001</td><td rowspan="8">#3</td><td>0</td><td>#17</td></tr>
<tr><td>1</td><td>#18</td></tr>
<tr><td>2</td><td>#19</td></tr>
<tr><td>3</td><td>#20</td></tr>
<tr><td>4</td><td>#21</td></tr>
<tr><td>5</td><td>#22</td></tr>
<tr><td rowspan="3">⋮</td><td>6</td><td>#23</td></tr>
<tr><td>7</td><td>#24</td></tr>
<tr><td>⋮</td><td>⋮</td><td>⋮</td></tr>
<tr><td rowspan="5">101</td><td rowspan="8">#8</td><td>0</td><td>#57</td></tr>
<tr><td>1</td><td>#58</td></tr>
<tr><td>2</td><td>#59</td></tr>
<tr><td>3</td><td>#60</td></tr>
<tr><td>4</td><td>#61</td></tr>
<tr><td rowspan="3">111</td><td>5</td><td>#62</td></tr>
<tr><td>6</td><td>#63</td></tr>
<tr><td>7</td><td>#64</td></tr>
</table>

TABLE

FIG.11

# MOBILE STATION APPARATUS AND RANDOM ACCESS METHOD

## TECHNICAL FIELD

The present invention relates to a radio communication mobile station apparatus and a radio communication method.

## BACKGROUND ART

Presently, studies are underway to use RACH (Random Access Channel) for initial access from a radio communication mobile station apparatus (hereinafter simply "mobile station") to a radio communication base station apparatus (hereinafter simply "base station"), in 3GPP RAN LTE (Long Term Evolution) (see Non-Patent Document 1). The RACH is utilized, for example, to make an association request and a resource request to the base station, and in initial access upon acquiring uplink transmission timing synchronization.

A mobile station transmitting a RACH signal selects one of a plurality of unique signatures in the RACH and transmits the selected signature to the base station to distinguish itself from other mobile stations transmitting RACH signals.

Moreover, in the RACH, taking into account that a plurality of signatures are transmitted from a plurality of mobile stations at the same time, studies are underway to use code sequences having low cross-correlation and high autocorrelation as signatures so as to demultiplex and detect those signatures in the base station. As a code sequence having such characteristics, the CAZAC (Constant Amplitude Zero Auto-Correlation) sequence is known, which is one of GCL (Generalized Chirp-Like) sequences (see Non-Patent Document 2).

Furthermore, to reduce the processing delay after the initial access, studies are underway to report, in the RACH, control information including the mobile station ID, the reason for RACH transmission, bandwidth allocation request information (QoS information, the amount of data, and so on), and downlink received quality information (see Non-Patent Document 3).

Non-patent Document 1: 3GPP TSG-RAN WG1 LTE Ad Hoc Meeting, R1-060047, NTT DoCoMo, NEC, Sharp, "Random Access Transmission in E-UTRA Uplink," Helsinki, Finland, 23-25 Jan., 2006

Non-patent Document 2: 3GPP TSG-RAN WG1 LTE Ad Hoc Meeting, R1-060046, NTT DoCoMo, NEC, Sharp, "Orthogonal Pilot Channel Structure in E-UTRA Uplink," Helsinki, Finland, 23-25 Jan., 2006

Non-patent Document 3: 3GPP TSG-RAN WG1 LTE Ad Hoc Meeting, R1-060480, Qualcomm, "Principles of RACH," Denver, USA, 13-17 Feb., 2006

## DISCLOSURE OF INVENTION

### Problems to be Solved by the Invention

Various studies are presently conducted for a method for reporting control information in the RACH, and efficient reporting of control information in the RACH meets a strong demand.

It is therefore an object of the present invention to provide a mobile station and radio communication method for efficiently reporting control information in the RACH.

### Means for Solving the Problem

The mobile station of the present invention adopts a configuration including: a selecting section that selects one code sequence from a base code sequence associated with control information to be reported and a plurality of derived code sequences derived from the associated base code sequence, or from a plurality of derived code sequences derived from the base code sequence associated with the control information to be reported; and a transmitting section that transmits the selected code sequence in a random access channel.



The radio transmission method of the present invention includes steps of: selecting one code sequence from a base code sequence associated with control information to be reported and a plurality of derived code sequences derived from the corresponding base code sequence, or from a plurality of derived code sequences derived from the base code sequence associated with the control information to be reported; and transmitting the selected code sequence in a random access channel.

### Advantageous Effect of the Invention

The present invention provides an advantage of reporting control information efficiently in the RACH.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a block diagram showing the configuration of the mobile station according to Embodiment 1;

FIG. 2 illustrates the CAZAC sequences according to Embodiment 1;

FIG. 3 shows the control information according to Embodiment 1;

FIG. 4 is the reference table (table example 1) according to Embodiment 1;

FIG. 5 is the reference table (a simplified version of the reference table in FIG. 4) according to Embodiment 1;

FIG. 6 shows an example of control information multiplexing according to Embodiment 1;

FIG. 7 shows the rate of occurrence of control information according to Embodiment 1;

FIG. 8 shows the reference table (table example 2) according to Embodiment 1;

FIG. 9 shows the reference table (table example 3) according to Embodiment 2;

FIG. 10 is a block diagram showing the configuration of the mobile station according to Embodiment 3; and

FIG. 11 is the reference table (table example 4) according to Embodiment 3.

## BEST MODE FOR CARRYING OUT THE INVENTION

Now, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

Embodiment 1

FIG. 1 shows the configuration of mobile station **10** of the present embodiment.

RACH generating section **11** is constructed of signature selecting section **111** and modulating section **112**, and generates a RACH signal as follows.

Signature selecting section **111** selects one of a plurality of unique code sequences as a signature, according to inputted control information, and outputs the selected code sequence to modulating section **112**.

The signature selection (code sequence selection) will be described later in detail.

Modulating section **112** modulates the signature (code sequence) to generate a RACH signal and outputs the RACH signal to multiplexing section **12**.

On the other hand, encoding section **13** encodes user data and outputs the encoded user data to modulating section **14**.

Modulating section **14** modulates the encoded user data and outputs the modulated user data to multiplexing section **12**.

Multiplexing section **12** time-domain-multiplexes the RACH signal and the user data, and outputs the time-domain-multiplexed RACH signal and user data to radio transmitting section **15**. That is, after the RACH signal transmission is completed, multiplexing section **12** outputs the user data to radio transmitting section **15**.

Radio transmitting section **15** performs radio processing including up-conversion on the RACH signal and user data, and transmits the result to the base station via antenna **16**.

Next, the signature selection (code sequence selection) will be described in detail.

In the present embodiment, GCL sequences or CAZAC sequences are used as signatures (code sequences).

GCL sequence $C_k(n)$ is given by equations 1 and 2. GCL sequence is a code sequence having high autocorrelation and low cross-correlation and having frequency response characteristics of constant amplitude. Here, N is an arbitrary integer and represents the sequence length. Moreover, k is an integer between 1 and N-1.

Further, n represents the n-th in the code sequence length N and is an integer between 0 and N-1. The GCL sequence found by equations 1 and 2 serves as the base code sequence.

(Equation 1)

$$C_k(n) = \alpha \cdot \exp\left(\frac{j2\pi k}{N}\left(\beta \cdot n + \frac{n(n+1)}{2}\right)\right) \quad [1]$$

where $N$ is an odd number

(Equation 2)

$$C_k(n) = \alpha \cdot \exp\left(\frac{j2\pi k}{N}\left(\beta \cdot n + \frac{n^2}{2}\right)\right) \quad [2]$$

where $N$ is an even number

Here, to acquire a large number of GCL sequences of low cross-correlations, the sequence length N is preferably an odd number and a prime number. Then, if the sequence length N is an odd number, by cyclically shifting, according to equation 3, the base code sequence given by equation 1, a plurality of derived code sequences $C_{k,m}(n)$ of respective numbers of cyclic shifts, can be acquired from a base code sequence $C_k(n)$.

(Equation 3)

$$C_{k,m}(n) = \alpha \cdot \exp\left(\frac{j2\pi k}{N}\left(\beta \cdot (n+m\cdot\Delta)\mathrm{mod}N + \frac{(n+m\cdot\Delta)\mathrm{mod}N \cdot ((n+m\cdot\Delta)\mathrm{mod}N+1)}{2}\right)\right) \quad [3]$$

Then, the GCL sequence where $\alpha$ and $\beta$ are 1 in equations 1 to 3 is a CAZAC sequence, and the CAZAC sequences are code sequences of the lowest cross-correlation among GCL sequences. That is, the base code sequence of CAZAC sequence $C_k(n)$ is found by equations 4 and 5. When the code sequence length N is an odd number, by cyclically shifting, according to equation 6, the base code sequence found by equation 4, with CAZAC sequences similar to GCL sequences, a plurality of derived code sequences $C_{k,m}(n)$ of respective numbers of cyclic shifts can be acquired from a base code sequence $C_k(n)$.

(Equation 4)

$$C_k(n) = \exp\left(\frac{j2\pi k}{N}\left(n + \frac{n(n+1)}{2}\right)\right) \quad [4]$$

where $N$ is an odd number

(Equation 5)

$$C_k(n) = \exp\left(\frac{j2\pi k}{N}\left(n + \frac{n^2}{2}\right)\right) \quad [5]$$

where $N$ is an even number

(Equation 6)

$$C_{k,m}(n) = \exp\left(\frac{j2\pi k}{N}\left((n+m\cdot\Delta)\mathrm{mod}N + \frac{(n+m\cdot\Delta)\mathrm{mod}N \cdot ((n+m\cdot\Delta)\mathrm{mod}N+1)}{2}\right)\right) \quad [6]$$

Although an example of cases will be explained below where the CAZAC sequence is used as a signature (code sequence), it is obvious from the above explanation that the present invention is also implemented when the GCL sequence is used as a signature (a code sequence).

FIG. **2** shows, in CAZAC sequences, eight derived code sequences $C_{1,0}(n)$ to $C_{1,7}(n)$ of the numbers of cyclic shifts m=0 to 7 (i.e., shift 0 to 7) that can be generated from a single base code sequence (CAZAC sequence #1), given that the sequence length N is 293, the cyclic shift value $\Delta$ is 36 and k is 1. If k is 2 or greater, equally, eight derived code sequences may be generated from a single base code sequence. That is, if CAZAC sequences #1 to #8 are used as the base code sequences, sixty four code sequences in total can be utilized as signatures. A base code sequence and a derived code sequence where the shift is zero are the same. Moreover, the cyclic shift value $\Delta$ needs to be set greater than the maximum propagation delay time of signatures. This results from occurring error detection of signatures in the base station, if a plurality of mobile stations transmit a plurality of signatures at the same time and delay waves are received with delays beyond the cyclic shift value $\Delta$, the base station is unable to decide whether it received signature with large delay time or it received signatures of different cyclic shift values. This maximum propagation delay time depends on the cell radius, that is, the distance of the maximum propagation path between the mobile station and the base station.

In the present embodiment, the base code sequences and derived code sequences acquired as such associated with control information are used as the signatures.

Signature selecting section **111** receives received quality information as, for example, control information shown in FIG. **3**. Pieces of control information "000" to "111" are associated with received quality (i.e., SINRs) shown in FIG. **3**, respectively, and one of pieces of the control information "000" to "111" is inputted to signature selecting section **111** as the control information to be reported.

Signature selecting section **111**, which has the table shown in FIG. **4**, selects one of the signatures (code sequences) with reference to the table shown in FIG. **4** based on the inputted control information to be reported.

In this table, as shown in FIG. 4, control information "000" to "111" are provided in association with CAZAC sequences #1 to #8, which are the base code sequences. Furthermore, for each CAZAC sequence #1 to #8, control information "000" to "111" are provided in association with derived code sequences of shifts 0 to 7 derived from each CAZAC sequence #1 to #8. FIG. 5 shows a simplified version of the table shown in FIG. 4.

In the table shown in FIG. 4, for example, the control information "000" is provided in association with CAZAC sequence #1 and derived code sequences of shifts 0 to 7 derived from CAZAC sequence #1. The derived code sequences of shifts 0 to 7 of CAZAC sequence #1 correspond to signatures #1 to #8, respectively. Moreover, control information "001" is provided in association with CAZAC sequence #2 and derived code sequences of shifts 0 to 7 derived from CAZAC sequence #2. The derived code sequences of shifts 0 to 7 of CAZAC sequence #2 correspond to signatures #9 to #16, respectively. The same applies to control information "010" to "111." That is, in the present embodiment, one piece of control information is associated with a single base code sequence and a plurality of unique derived code sequences derived from this single base code sequence. Moreover, the unique 64 code sequences are associated with signatures #1 to #64.

Then, when, for example, "000" is inputted as the control information to be reported, signature selecting section **111** selects one code sequence from code sequences of shifts 0 to 7 of CAZAC sequence #1 as the signature. The base code sequence and a derived code sequence of shift 0 are the same, so that signature selecting section **111** selects one code sequence as a signature from the base code sequence corresponding control information to be reported and a plurality of derived code sequences derived from the corresponding base code sequence, or from a plurality of derived code sequences derived from the base code sequence corresponding to the control information to be reported.

Consequently, according to the present embodiment, the mobile station utilizes signatures as control information upon reporting control information in the RACH, so that the mobile station does not need to transmit control information in addition to signatures.

Moreover, the base station that receives a signature can detect control information by detecting the signature at the same time. In this way, according to the present embodiment, control information can be reported efficiently in the RACH.

In the present embodiment, taking into account that a plurality of mobile stations transmit the identical control information at the same time, it is preferable that signature selecting section **111** selects one of the eight code sequences corresponding to the inputted control information on a random basis. For example, when the control information "000" is inputted, taking into account that a plurality of mobile stations report identical control information "000" at the same time, signature selecting section **111** preferably selects one of code sequences (signatures #1 to #8) of shifts #0 to #7 of CAZAC sequence #1 corresponding to the control information "000" on a random basis. Even when a plurality of mobile stations transmit the identical control information at the same time, this random selection reduces the likelihood of selecting the same code sequence between separate mobile stations, so that the base station is more likely to improve the likelihood of demultiplexing and detecting the signatures transmitted from the individual mobile stations.

Moreover, a configuration may also be employed where signature selecting section **111** may select the code sequence associated with the control information to be reported from the code sequences prepared in advance (here, 64 code sequences #1 to #64), or select the CAZAC sequence number k and the number of shifts m associated with the control information to be reported to generate a code sequence $C_{k,m}(n)$ from equation 6 every selection.

Whichever configuration is employed, as a result, signature selecting section **111** selects one of signatures (code sequences) based on control information to be reported.

Here, a plurality of derived code sequences derived from a single base code sequence are completely orthogonal, and the cross-correlation is zero between these derived code sequences.

On the other hand, although cross-correlation between a plurality of base code sequences is relatively low, these base code sequences are not completely orthogonal, and the cross-correlation is not zero. The same applies to derived code sequences derived from different code sequences.

That is, a plurality of derived code sequences derived from a single base code sequence have a feature of having a lower cross-correlation than the cross-correlation between a plurality of base code sequences and the cross-correlation between derived code sequences derived from different code sequences.

That is, in the table shown in FIG. 4, with CAZAC sequence #1 corresponding to control information "000" and CAZAC sequence #2 corresponding to control information "001," the cross-correlation between the code sequences of shifts 0 to 7 of CAZAC sequence #1 is lower than the cross-correlation between CAZAC sequence #1 and CAZAC sequence #2 and the cross-correlation between the code sequences of shifts 0 to 7 of CAZAC sequence #1 and the code sequences of shifts 0 to 7 of CAZAC sequence #2. That is, the cross-correlation between the identical control information can be lower than the cross-correlation between different control information by adopting the associations shown in FIG. 4.

That is, as shown in FIG. 6, even when identical control information ("000") is reported at the same time from a plurality of mobile stations (mobile stations A to C) and a plurality of signatures are multiplexed in the RACH, if code sequences with unique numbers of shifts (shifts 0, 3 and 7) derived from the same base code sequence (CAZAC sequence #1) are multiplexed as signatures, intersymbol interference between the signatures is ideally zero, and the performance of demultiplexing and detecting signatures in the base station hardly degrades compared with a case where multiplexing is not performed, even when the number of multiplexing increases.

On the other hand, as shown in FIG. 6, when there is a mobile station (mobile station D) reporting different control information ("001"), code sequence (shift 2) derived from the different base code sequence (CAZAC sequence #2) is multiplexed as a signature, and so the performance of demultiplexing and detecting signatures in the base station degrades when the number of multiplexing increases.

That is, the present embodiment is effective particularly when the identical control information is reported from a plurality of mobile stations at the same time. The specific and identical control information is more likely to be reported from a plurality of mobile stations at the same time when the rate of occurrence of the pieces of control information is less uniform.

For example, in a situation where there is a train station in the cell and there are always a large number of mobile stations in a specific location in the cell, the mobile stations in this specific location are likely to have nearly uniform received quality, so that the specific and identical control information is likely to have a high rate of occurrence and are reported from a plurality of mobile stations at the same time.

Moreover, received quality in a mobile station increases closer to the center of a cell where the base station is located and gradually decreases farther from the center of the cell. Further, this area increases as farther from the center of the

cell. Accordingly, in the situation where mobile stations are uniformly distributed in the cell, as shown in FIG. 7, it is possible that when the rate of occurrence is high at lower received quality (SINR), there are a large number of mobile stations reporting control information showing lower received quality (SINR). Accordingly, in the situation as such, for control information showing lower received quality, the identical control information is likely to be reported from a plurality of mobile stations at the same time.

That is, in this situation, the specific and identical control information is likely to be reported from a plurality of mobile stations at the same time.

In this way, according to the present embodiment, it is possible to keep the rate of detection of signatures and control information at the base station high, in the situation where there are a large number of mobile stations reporting the identical control information in the RACH.

When the cell radius is small, the table shown in FIG. 8 may be used instead of the table shown in FIG. 4. That is, the maximum propagation delay time of the signatures is small and the cyclic shift value A can be less when the cell radius is small, so that, to decrease the cross-correlation between different pieces of control information, as shown in FIG. 8, a plurality of pieces of control information may be associated with a single base code sequence. In the table shown in FIG. 8, control information "000" to "011" are associated with CAZAC sequence #1, and control information "000" is associated with the code sequence of shifts 0 to 7 of CAZAC sequence #1, control information "001" is associated with the code sequence of shifts 8 to 15 of CAZAC sequence #1, control information "010" is associated with the code sequence of shifts 16 to 23 of CAZAC sequence #1, and control information "011" is associated with the code sequence of shifts 24 to 31 of CAZAC sequence #1. Moreover, control information "100" to "111" are associated with CAZAC sequence #2, control information "100" is associated with the code sequence of shifts 0 to 7 of CAZAC sequence #2, control information "101" is associated with the code sequence of shifts 8 to 15 of CAZAC sequence #2, control information "110" is associated with the code sequence of shifts 16 to 23 of CAZAC sequence #2, and control information "111" is associated with the code sequence of shifts 24 to 31 of CAZAC sequence #2. These associations make it possible to associate different pieces of control information with derived code sequences of different shift values derived from a single base code sequence, so that it is possible to decrease the cross-correlation between different pieces of control information and keep the rate of detection of signatures and control information at the base station high even when there are a large number of mobile stations reporting the different control information at the same time.

Embodiment 2

As shown in FIG. 7 above, there are cases where the rate of occurrence is not uniform between control information in the cell. That is, in such a case, it is preferable to assign more code sequences to control information occurred much.

Now, the present embodiment does not employ tables (FIGS. 4, 5 and 8) that provide various pieces of control information in association with the same number of code sequences as in Embodiment 1. Instead, the present embodiment employs a table that associates control information of a higher rate of occurrence with more base code sequences or more derived code sequences, as shown in FIG. 9.

When control information of high rate of occurrence is reported from a plurality of mobile stations at the same time, use of this table reduces the rate of transmitting the same code sequences from a plurality of mobile stations, so that it is possible to reduce the rate of collisions between code sequences and to keep the rate of detection of signatures and control information at the base station high.

Moreover, at this time, when one piece of control information is provided in association with a plurality of base code sequences, to keep the cross-correlation between the identical control information low, it is preferable to associate derived code sequences derived from a single base code sequence preferentially. For example, when one piece of control information like control information "000" in FIG. 9 is provided in association with CAZAC sequences #1 and #2, control information "000" is preferentially associated with all derived code sequences derived from CAZAC sequence #1 and, the rest of the piece is associated with part of the derived code sequences derived from CAZAC sequence #2. That is, in the table shown in FIG. 9, one piece of control information is provided in association with a plurality of base code sequences and all of the derived code sequences derived from at least one of a plurality of the base code sequences.

Moreover, although a case has been described above with the present embodiment where the number of code sequences assigned to each control information is determined according to the rate of occurrence of each control information, the number of code sequences assigned to each control information is determined according to, for example, the significance, priority, the number of retransmissions, and QoS of each control information. That is, the present embodiment employs the table that provides the pieces of control information in association with different numbers of base code sequences or different numbers of derived code sequences.

Embodiment 3

The rate of occurrence of control information changes in a cell. For example, at a single place in a cell, there are a number of mobile stations in daytime larger than in nighttime, and the rate of occurrence for the specific and identical control information is higher in daytime than nighttime in such a case.

Then, according to the present embodiment, the number of base code sequences or the number of derived code sequences associated with pieces of control information change according to changes of the rate of occurrence of control information.

FIG. 10 shows the configuration of mobile station 30 according to the present embodiment. In FIG. 10, the same reference numerals will be assigned to the same component in FIG. 1 (Embodiment 1), and description thereof will be omitted.

Radio receiving section 31 receives control signal transmitted from the base station via antenna 16, performs radio processing including down-conversion of the control signal, and outputs the control signal to demodulating section 32. This control signal is transmitted in the broadcast control channel from the base station and designates to change the associations between control information and the code sequences in the table according to the rate of occurrence of control information. The rate of occurrence of control information is measured in the base station receiving signatures.

Demodulating section 32 demodulates the control signal and outputs the demodulated control signal to control section 33.

Control section 33 changes the associations in the table provided in the signature selecting section 111 according to the control signal. For example, control section 33 changes the associations in the table shown in FIG. 9 above as shown in FIG. 11. FIG. 11 shows a case where the number of code sequences associated with control information "000" is increased due to an increased rate of occurrence of control information "000" and where the number of code sequences associated with control information "001" is decreased due to a decreased rate of occurrence of control information "001."

In this way, according to the present embodiment, the number of code sequences associated with each control information is changed according to changes of rate of occurrence of control information, so that it is possible to keep the rate of

detection of signatures and control information at the base station high even when the rate of occurrence of control information is changed.

The embodiments of the present invention have been explained.

Although cases have been explained above with the embodiments where signature selecting section **111** adopts the configuration of the tables above, the tables above may also be adopted outside of signature selecting section **111**. Moreover, the tables are not particularly required if the control information and the code sequence are associated in different manners.

Moreover, in the embodiments, although GCL sequence and CAZAC sequence are explained as an example of code sequences, any code sequence may be used if levels of cross-correlations vary between the code sequences.

Moreover, control information reported from the mobile station is not limited to received quality information. Other control information includes, for example, a mobile station ID, a reason of RACH transmission, bandwidth allocation request information (Qos information and an amount of data and so on), RACH transmission power, and difference between the maximum value of RACH transmission power and present transmission power.

Moreover, the mobiles station and the base station according to the embodiments may be referred to as "UE" and "Node-B."

Moreover, although cases have been described with the embodiments above where the present invention is configured by hardware, the present invention may be implemented by software.

Each function block employed in the description of the aforementioned embodiment may typically be implemented as an LSI constituted by an integrated circuit.

These may be individual chips or partially or totally contained on a single chip. "LSI" is adopted here but this may also be referred to as "IC," "system LSI," "super LSI" or "ultra LSI" depending on differing extents of integration.

Further, the method of circuit integration is not limited to LSI's, and implementation using dedicated circuitry or general purpose processors is also possible.

After LSI manufacture, utilization of an FPGA (Field Programmable Gate Array) or a reconfigurable processor where connections and settings of circuit cells within an LSI can be reconfigured is also possible.

Further, if integrated circuit technology comes out to replace LSI's as a result of the advancement of semiconductor technology or a derivative other technology, it is naturally also possible to carry out function block integration using this technology. Application of biotechnology is also possible.

The disclosure of Japanese Patent Application No. 2006-076995, filed on Mar. 20, 2006, including the specification, drawings and abstract, is incorporated herein by reference in its entirety.

## INDUSTRIAL APPLICABILITY

The present invention is suitable for use in transmission of uplink common channels including a RACH.

The invention claimed is:

**1**. A mobile station apparatus comprising:

a receiving unit configured to receive control information;

a selecting unit configured to randomly select a sequence from a plurality of sequences contained in one group of a plurality of groups, into which a predetermined number of sequences that are generated from a plurality of base sequences are grouped and which are respectively associated with different amounts of data or reception qualities, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts; and

a transmitting unit configured to transmit the selected sequence,

wherein a position at which the predetermined number of sequences are partitioned is determined based on the control information, and a number of sequences contained in each of the plurality of groups varies in accordance with the control information.

**2**. The mobile station apparatus according to claim **1**, wherein said transmitting unit transmits the selected sequence on a random access channel.

**3**. The mobile station apparatus according to claim **1**, wherein the number of sequences contained in each of the plurality of groups is different.

**4**. The mobile station apparatus according to claim **1**, wherein the predetermined number of sequences are grouped by partitioning the predetermined number of sequences, which are arranged in an increasing order of sequence indices of the base sequences.

**5**. The mobile station apparatus according to claim **1**, wherein one group associated with one of the different amounts of data or reception qualities is comprised of all of sequences that are generated from at least one of the base sequences.

**6**. The mobile station apparatus according to claim **1**, wherein one group associated with one of the different amounts of data or reception qualities is comprised only of sequences that are generated from at least one of the base sequences.

**7**. The mobile station apparatus according to claim **1**, wherein a group associated with the amount of data or reception quality with higher probability of occurrence is comprised of a greater number of sequences.

**8**. The mobile station apparatus according to claim **1**, wherein the number of the sequences contained in each of the plurality of groups varies in accordance with probability of occurrence of the amount of data or reception quality.

**9**. The mobile station apparatus according to claim **1**, wherein the base sequence is a Generalized Chirp-like (GCL) sequence.

**10**. A random access method comprising:

receiving control information;

grouping a predetermined number of sequences that are generated from a plurality of base sequences into a plurality of groups, which are respectively associated with different amounts of data or reception qualities, by partitioning the predetermined number of sequences, in which sequences generated from the same base sequence and having different cyclic shifts are arranged in an increasing order of the cyclic shifts; and

randomly selecting a sequence from a plurality of sequences contained in one group of the plurality of groups,

wherein a position at which the predetermined number of sequences are partitioned is determined based on the control information, and a number of sequences contained in each of the plurality of groups varies in accordance with the control information.

* * * * *

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**April 18, 2019**

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**U.S. PATENT:** ***9,001,774***
**ISSUE DATE:** ***April 07, 2015***

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**Under Secretary of Commerce for Intellectual Property**
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2:19-cv-00066-JRG

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(12) **United States Patent**
**Khan**

(10) **Patent No.:** **US 9,001,774 B2**
(45) **Date of Patent:** **Apr. 7, 2015**

(54) **SYSTEM AND METHOD FOR CHANNEL ESTIMATION IN A DELAY DIVERSITY WIRELESS COMMUNICATION SYSTEM**

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(72) Inventor: **Farooq Khan**, Allen, TX (US)

(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-Si (KR)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/078,204**

(22) Filed: **Nov. 12, 2013**

(65) **Prior Publication Data**

US 2014/0072061 A1 Mar. 13, 2014

**Related U.S. Application Data**

(63) Continuation of application No. 13/093,568, filed on Apr. 25, 2011, now Pat. No. 8,582,519, which is a continuation of application No. 11/390,125, filed on Mar. 27, 2006, now Pat. No. 7,953,039.

(60) Provisional application No. 60/673,574, filed on Apr. 21, 2005, provisional application No. 60/673,674, filed on Apr. 21, 2005, provisional application No. 60/679,026, filed on May 9, 2005.

(51) **Int. Cl.**
***H04W 72/04*** (2009.01)
***H04L 27/26*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC .......... ***H04L 27/2601*** (2013.01); ***H04B 7/0671*** (2013.01); ***H04B 7/0684*** (2013.01); ***H04L 25/022*** (2013.01); ***H04L 25/0228*** (2013.01); ***H04L 27/261*** (2013.01); ***H04L 27/2647*** (2013.01); ***H04L 25/03955*** (2013.01); ***H04L 5/0048*** (2013.01); *H04B 7/12* (2013.01)

(58) **Field of Classification Search**
USPC ......... 370/328, 329, 332, 338, 343, 203, 208, 370/210, 292, 480, 491, 498, 500; 375/260, 375/267, 299
See application file for complete search history.

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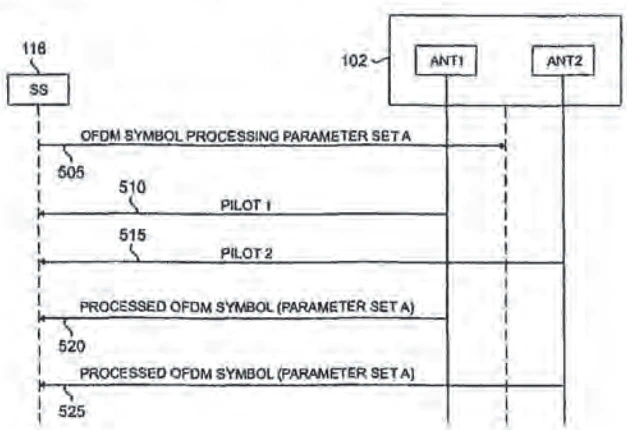
*Primary Examiner* — Cong Tran

(57) **ABSTRACT**

A method of controlling downlink transmissions to a subscriber station capable of communicating with a base station of an orthogonal frequency division multiplexing (OFDM) network. The method comprises the steps of: receiving a first pilot signal from a first base station antenna; receiving a second pilot signal from a second base station antenna; and estimating the channel between the base station and subscriber station based on the received first and second pilot signals. The method also comprises determining a set of OFDM symbol processing parameters based on the step of estimating the channel and transmitting the OFDM symbol processing parameters to the base station. The base station uses the OFDM symbol processing parameters to control the relative gains and the relative delays of OFDM symbols transmitted from the first and second antennas.

**10 Claims, 8 Drawing Sheets**



(51) **Int. Cl.**

| | |
|---|---|
| *H04B 7/06* | (2006.01) |
| *H04L 25/02* | (2006.01) |
| *H04L 25/03* | (2006.01) |
| *H04L 5/00* | (2006.01) |
| *H04B 7/12* | (2006.01) |

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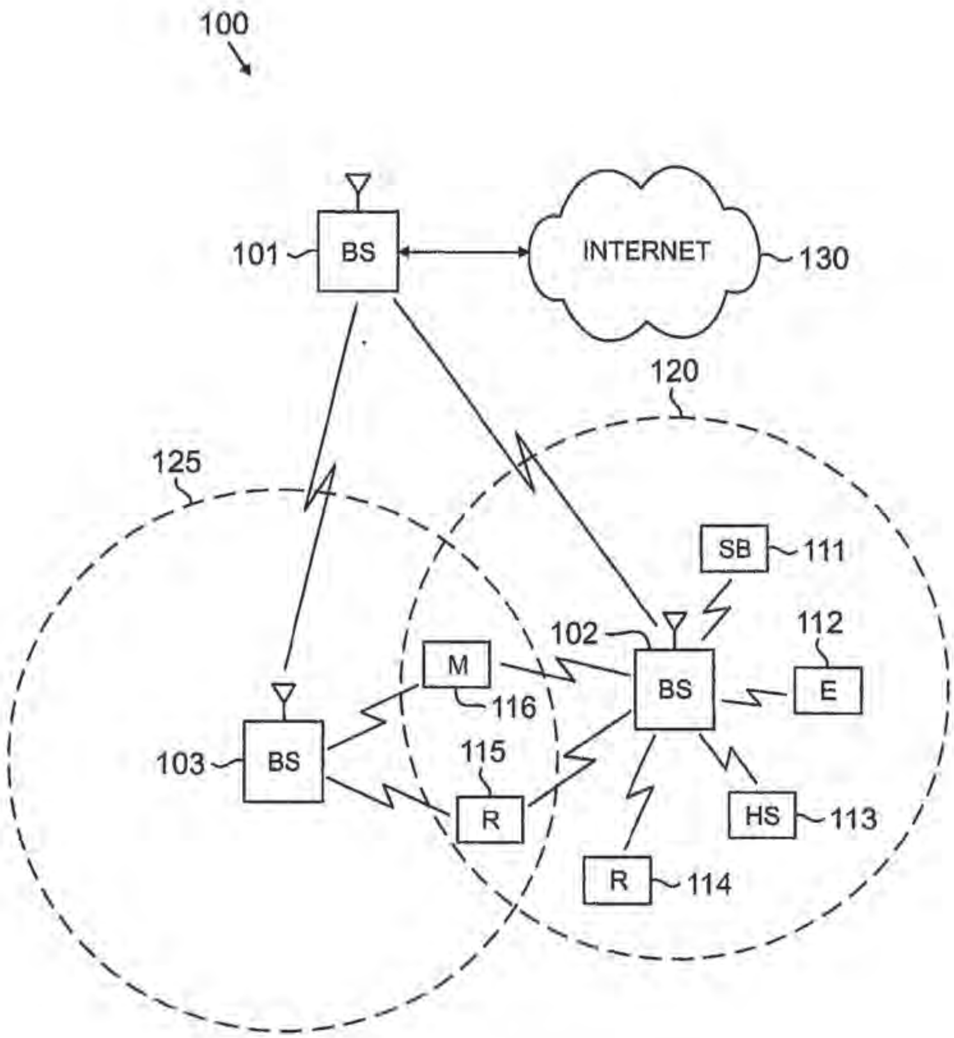
100
101
BS
INTERNET
130
120
125
SB
111
102
112
M
BS
E
116
103
BS
115
R
HS
113
R
114

FIG. 1

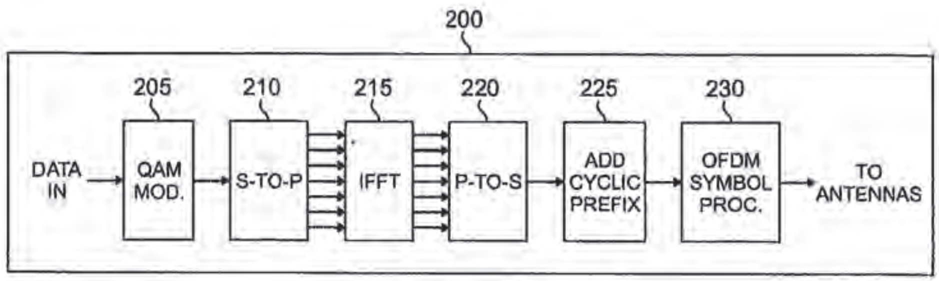
200
205
210
215
220
225
230
DATA IN
QAM MOD.
S-TO-P
IFFT
P-TO-S
ADD CYCLIC PREFIX
OFDM SYMBOL PROC.
TO ANTENNAS

FIG. 2A

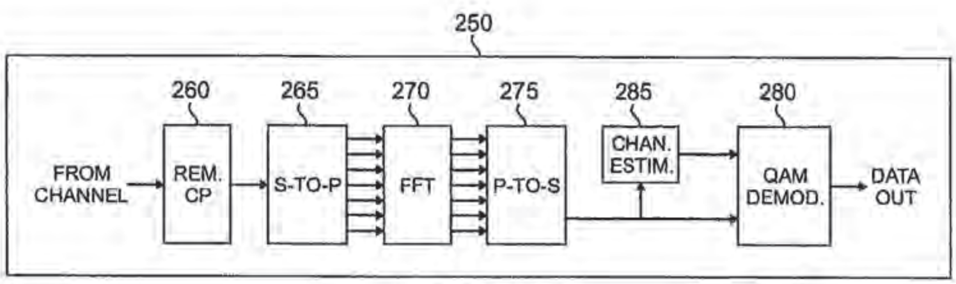
250
260
265
270
275
285
280
FROM CHANNEL
REM. CP
S-TO-P
FFT
P-TO-S
CHAN. ESTIM.
QAM DEMOD.
DATA OUT

FIG. 2B

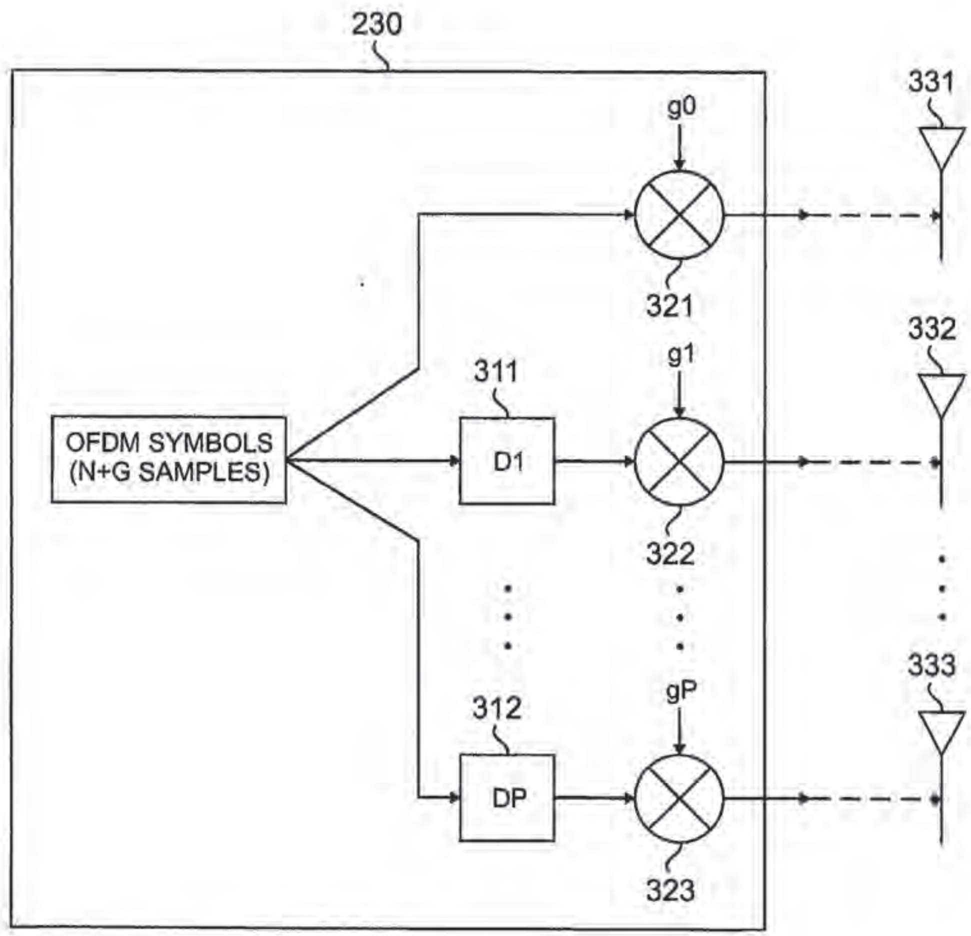
230
331
g0
321
332
g1
311
OFDM SYMBOLS
(N+G SAMPLES)
D1
322
333
gP
312
DP
323

FIG. 3

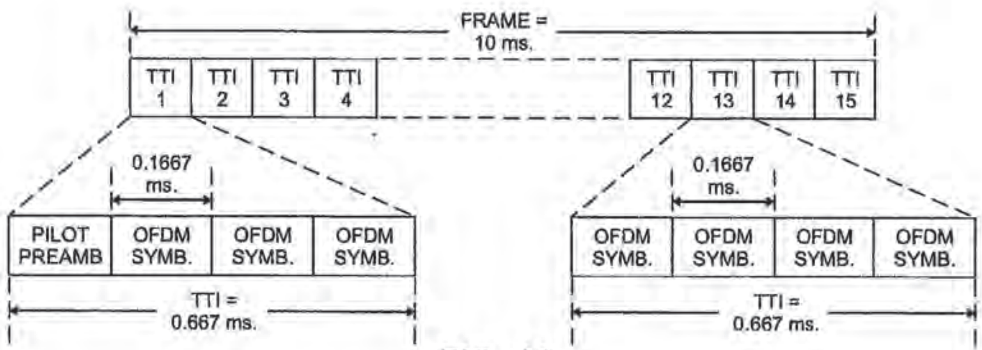
FRAME =
10 ms.
TTI 1
TTI 2
TTI 3
TTI 4
TTI 12
TTI 13
TTI 14
TTI 15
0.1667 ms.
PILOT PREAMB
OFDM SYMB.
OFDM SYMB.
OFDM SYMB.
TTI =
0.667 ms.
0.1667 ms.
OFDM SYMB.
OFDM SYMB.
OFDM SYMB.
OFDM SYMB.
TTI =
0.667 ms.

FIG. 4A

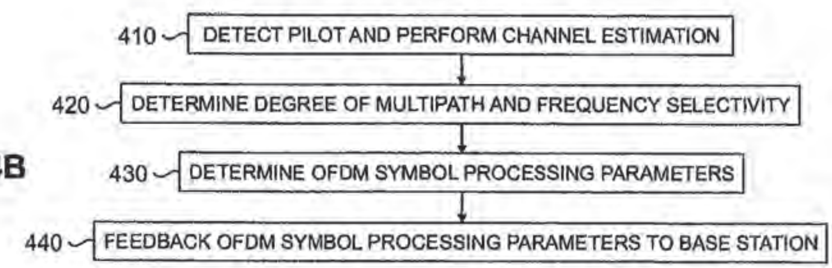
410 DETECT PILOT AND PERFORM CHANNEL ESTIMATION
420 DETERMINE DEGREE OF MULTIPATH AND FREQUENCY SELECTIVITY
430 DETERMINE OFDM SYMBOL PROCESSING PARAMETERS
440 FEEDBACK OFDM SYMBOL PROCESSING PARAMETERS TO BASE STATION

FIG. 4B

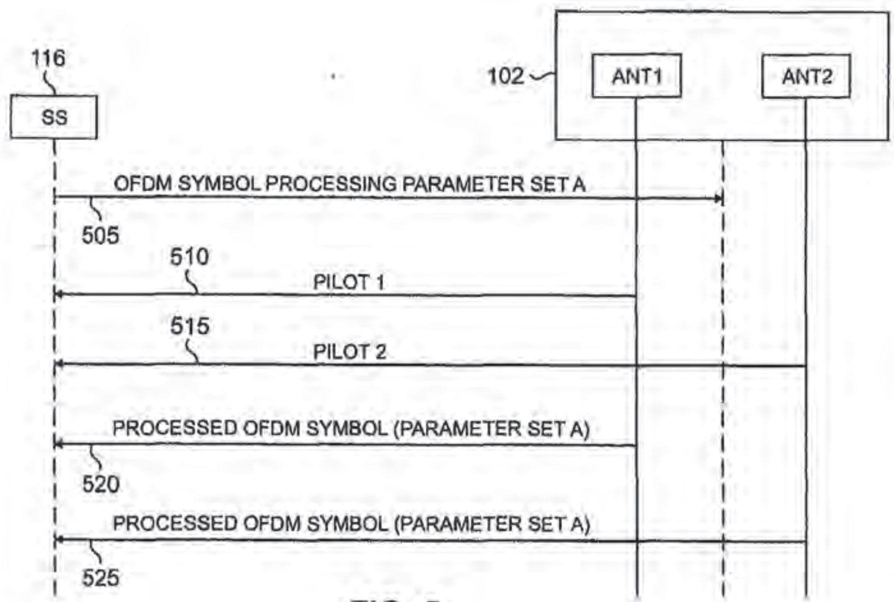
116
SS
102
ANT1
ANT2
OFDM SYMBOL PROCESSING PARAMETER SET A
505
510
PILOT 1
515
PILOT 2
PROCESSED OFDM SYMBOL (PARAMETER SET A)
520
PROCESSED OFDM SYMBOL (PARAMETER SET A)
525

FIG. 5

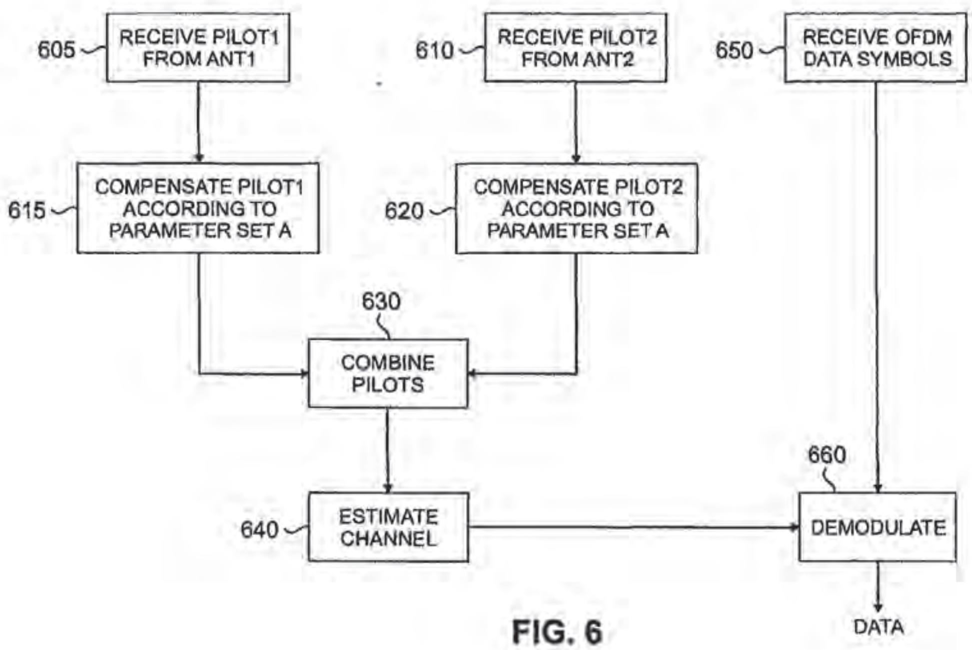
605
RECEIVE PILOT1 FROM ANT1
610
RECEIVE PILOT2 FROM ANT2
650
RECEIVE OFDM DATA SYMBOLS
615
COMPENSATE PILOT1 ACCORDING TO PARAMETER SET A
620
COMPENSATE PILOT2 ACCORDING TO PARAMETER SET A
630
COMBINE PILOTS
660
640
ESTIMATE CHANNEL
DEMODULATE
DATA

FIG. 6

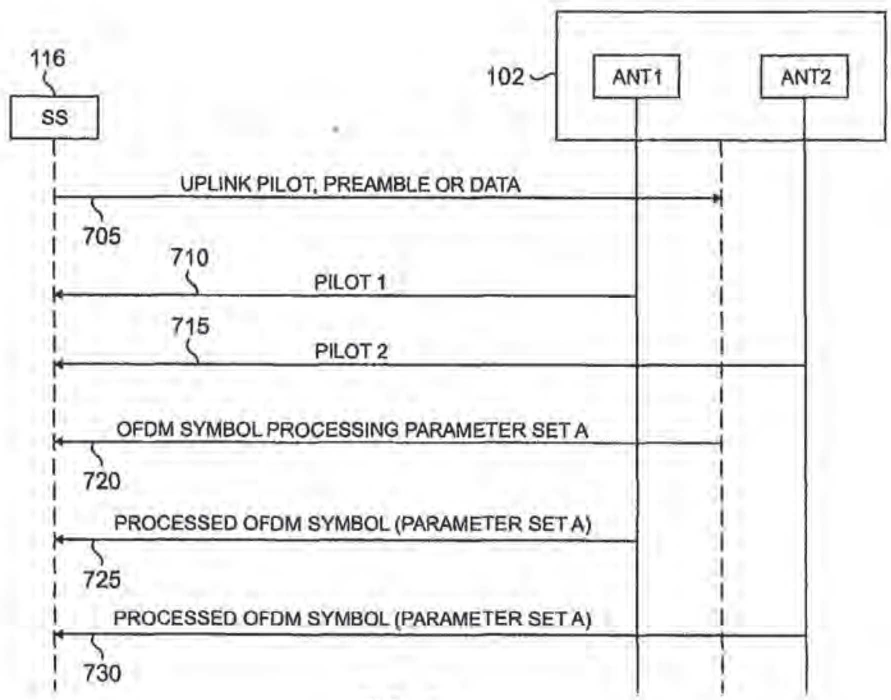
116
SS
102
ANT1
ANT2
UPLINK PILOT, PREAMBLE OR DATA
705
710
PILOT 1
715
PILOT 2
OFDM SYMBOL PROCESSING PARAMETER SET A
720
PROCESSED OFDM SYMBOL (PARAMETER SET A)
725
PROCESSED OFDM SYMBOL (PARAMETER SET A)
730

FIG. 7

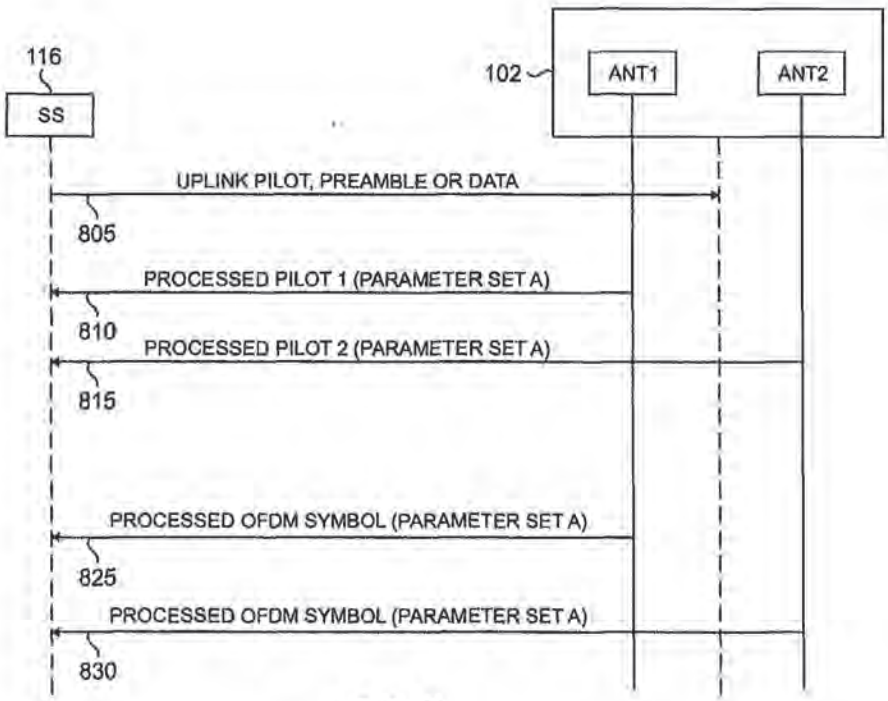
116
SS
102
ANT1
ANT2
UPLINK PILOT, PREAMBLE OR DATA
805
PROCESSED PILOT 1 (PARAMETER SET A)
810
PROCESSED PILOT 2 (PARAMETER SET A)
815
PROCESSED OFDM SYMBOL (PARAMETER SET A)
825
PROCESSED OFDM SYMBOL (PARAMETER SET A)
830

FIG. 8

# SYSTEM AND METHOD FOR CHANNEL ESTIMATION IN A DELAY DIVERSITY WIRELESS COMMUNICATION SYSTEM

## CROSS-REFERENCE TO RELATED APPLICATIONS AND CLAIM OF PRIORITY

The present application is claims priority as a continuation of, and incorporates by reference, U.S. Non-Provisional Application Ser. No. 13/093,568 entitled "SYSTEM AND METHOD FOR CHANNEL ESTIMATION IN A DELAY DIVERSITY WIRELESS COMMUNICATION SYSTEM" filed Apr. 25, 2011, now U.S. Pat. No. 8,582,519, which is a continuation of U.S. Non-Provisional Application Ser. No. 11/390,125 entitled "SYSTEM AND METHOD FOR CHANNEL ESTIMATION IN A DELAY DIVERSITY WIRELESS COMMUNICATION SYSTEM" and filed Mar. 27, 2006, now U.S. Pat. No. 7,953,039, to which the present application also claims priority and incorporates by reference. The present application further claims priority through the above-identified applications to, and incorporates by reference, U.S. Provisional Patent Applications Nos. 60/673,574 and 60/673,674, both entitled "DIVERSITY TRANSMISSION IN AN OFDM WIRELESS COMMUNICATION SYSTEM" and filed Apr. 21, 2005, and to U.S. Provisional Patent Application No. 60/679,026, entitled "CHANNEL ESTIMATION IN A DELAY DIVERSITY WIRELESS COMMUNICATION SYSTEM" and filed May 9, 2005.

## TECHNICAL FIELD OF THE INVENTION

The present disclosure relates generally to wireless communications and, more specifically, to an apparatus and method for performing channel estimation in an orthogonal frequency division multiplexing (OFDM) network or an orthogonal frequency division multiple access (OFDMA) network.

## BACKGROUND OF THE INVENTION

Conventional orthogonal frequency division multiplexing (OFDM) networks and orthogonal frequency division multiple access (OFDMA) network are able to improve the reliability of the channel by spreading and/or coding data traffic and control signals over multiple subcarriers (i.e., tones). However, if the channel is flat, frequency diversity cannot be achieved. In order to overcome this, it is possible to introduce artificial frequency diversity into the transmitted signal. A technique for artificially introducing frequency diversity into an OFDM environment was disclosed in U.S. patent application Ser. No. 11/327,799, filed on Jan. 6, 2006 and incorporated by reference above. In the device disclosed in Ser. No. 11/327,799, multiple copies of the same OFDM symbol are delayed by different delay values, then amplified by the same or different gain values, and then transmitted from different antennas. This artificially introduces frequency-selective fading in the OFDM channel, thereby allowing frequency selectivity to be exploited using frequency-domain scheduling for low-to-medium speed mobile devices or frequency diversity for higher speed mobile devices.

However, when selecting the symbol processing parameters (i.e., delay values and the gain values) applied to the OFDM symbols, it is important to take into consideration the user channel type and the mobile speed. To accomplish this, channel estimation is performed and the symbol processing parameters are determined based on the channel estimates and mobile speed. Therefore, there is a need for improved



apparatuses and methods for performing channel estimation in an OFDM wireless network that artificially introduces frequency diversity by delaying and amplifying multiple copies of the same OFDM symbol and then transmitting the delayed and amplified OFDM symbols from different transmit antennas.

## SUMMARY OF THE INVENTION

A method of controlling downlink transmissions to a subscriber station is provided for use in a subscriber station capable of communicating with a base station of an orthogonal frequency division multiplexing (OFDM) network. The method comprises the steps of: receiving a first pilot signal from a first antenna of the base station; receiving a second pilot signal from a second antenna of the base station; estimating the channel between the base station and subscriber station based on the received first and second pilot signals; determining a set of OFDM symbol processing parameters based on the step of estimating the channel, wherein the OFDM symbol processing parameters are usable by the base station to control the relative gains and the relative delays of OFDM symbols transmitted from the first and second antennas; and transmitting the OFDM symbol processing parameter set to the base station.

According to another embodiment of the present disclosure, a subscriber station capable of communicating with a base station of an orthogonal frequency division multiplexing (OFDM) network is provided. The subscriber station comprises: receive path circuitry capable of receiving a first pilot signal from a first antenna of the base station and receiving a second pilot signal from a second antenna of the base station; and channel estimating circuitry capable of estimating the channel between the base station and subscriber station based on the received first and second pilot signals and capable of determining a set of OFDM symbol processing parameters based on a channel quality estimate. The OFDM symbol processing parameters are usable by the base station to control the relative gains and the relative delays of OFDM symbols transmitted from the first and second antennas and wherein the subscriber station is capable of transmitting the OFDM symbol processing parameters to the base station.

According to yet another embodiment of the present disclosure, a base station is provided for use in an orthogonal frequency division multiplexing (OFDM) network. The base station comprises: 1) receive path circuitry capable of receiving an uplink signal from a subscriber station, estimating the channel between the base station and subscriber station based on the received uplink signal, and determining a set of OFDM symbol processing parameters based on a channel quality estimate; and 2) transmit path circuitry capable of using the OFDM symbol processing parameters to control the relative gains and the relative delays of processed OFDM symbols transmitted from a first antenna and a second antenna of the base station. The base station is capable of transmitting the OFDM symbol processing parameters to the subscriber station. The OFDM symbol processing parameters are based on the multipath characteristics and the frequency selectivity characteristics of the channel.

Before undertaking the DETAILED DESCRIPTION OF THE INVENTION below, it may be advantageous to set forth definitions of certain words and phrases used throughout this patent document: the terms "include" and "comprise," as well as derivatives thereof, mean inclusion without limitation; the term "or," is inclusive, meaning and/or; the term "each" means every one of at least a subset of the identified items; the phrases "associated with" and "associated therewith," as well

as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like; and the term "controller" means any device, system or part thereof that controls at least one operation, such a device may be implemented in hardware, firmware or software, or some combination of at least two of the same. It should be noted that the functionality associated with any particular controller may be centralized or distributed, whether locally or remotely. Definitions for certain words and phrases are provided throughout this patent document, those of ordinary skill in the art should understand that in many, if not most instances, such definitions apply to prior, as well as future uses of such defined words and phrases.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present disclosure and its advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, in which like reference numerals represent like parts:

FIG. 1 illustrates an exemplary orthogonal frequency division multiplexing (OFDM) wireless network that is capable of performing channel estimation according to the principles of the present disclosure;

FIG. 2A is a high-level diagram of the orthogonal frequency division multiplexing (OFDM) transmit path in a base station according to one embodiment of the disclosure;

FIG. 2B is a high-level diagram of the orthogonal frequency division multiplexing (OFDM) receive path in a subscriber station according to one embodiment of the disclosure;

FIG. 3 illustrates the OFDM symbol processing block in the base station in greater detail according to an exemplary embodiment of the present disclosure;

FIG. 4A illustrates data traffic transmitted in the downlink from a base station to a subscriber station according to an exemplary embodiment of the present disclosure;

FIG. 4B is a flow diagram illustrating the determination of the user channel type based on the measurements on the preamble according to an exemplary embodiment of the disclosure;

FIG. 5 is a message flow diagram illustrating the transmission of OFDM symbols from a base station to a subscriber station according to the principles of the disclosure;

FIG. 6 is a flow diagram illustrating the processing of pilot signals and OFDM data symbols according to an exemplary embodiment of the present disclosure;

FIG. 7 is a message flow diagram illustrating the transmission of OFDM symbols from a base station to a subscriber station according to another embodiment of the disclosure; and

FIG. 8 is a message flow diagram illustrating the transmission of OFDM symbols from a base station to a subscriber station according to another embodiment of the disclosure.

## DETAILED DESCRIPTION OF THE INVENTION

FIGS. 1 through 8, discussed below, and the various embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged wireless network.

The present disclosure is directed to apparatuses and algorithms for channel estimation and channel quality estimation for demodulation and data rate selection in an orthogonal frequency division multiplexing (OFDM) wireless network that uses delayed diversity. Such a delayed diversity wireless network was disclosed previously U.S. patent application Ser. No. 11/327,799, incorporated by reference above. The present disclosure uses a number of factors, including user channel type and mobile speed, to select OFDM symbol processing parameters (i.e., delays D1, D2, . . . , DP and gains $g_0, g_1, \ldots, g_P$) for OFDM symbols transmitted from up to P antennas (i.e., ANT1 to ANTP). Therefore, different OFDM symbol processing parameters may be used to transmit to different mobile devices that are scheduled simultaneously, depending upon their channel types.

It is noted that the scope of the present disclosure is not limited to orthogonal frequency division multiplexing (OFDM) wireless networks. The present disclosure is also applicable to orthogonal frequency division multiple access (OFDMA) wireless networks. However, for simplicity and brevity, the embodiments described below are directed to OFDM wireless networks, except where otherwise noted or where the context indicates otherwise.

For relatively low-speed mobile devices, it is usually possible to track changes in the channel, thereby allowing channel sensitive scheduling to improve performance. Thus, the OFDM symbol processing parameters may be selected in such a way that relatively large coherence bandwidth results. That is, a relatively larger number of subcarriers experience similar fading. This goal may be achieved by keeping the delays for OFDM symbols from different antennas relatively small. A mobile device may then be scheduled on a subband consisting of contiguous subcarriers.

For relatively high-speed mobile devices, channel quality variations cannot be tracked accurately, so that frequency-diversity may be helpful. Thus, the OFDM symbol processing parameters are selected in such a way that relatively small coherence bandwidth results. That is, potentially independent fading may occur from subcarrier to subcarrier. This goal may be achieved by having relatively large delays for OFDM symbols transmitted from different antennas.

The symbol processing parameters may also be selected based on the degree of frequency-selectivity already present in the channel. For example, if a channel already has a lot of multipath effects and is, therefore, frequency selective, there may be little or no need for additional frequency selectivity. The OFDM symbol processing parameters may be selected on a user-by-user basis because different mobile devices experience different channel types.

FIG. 1 illustrates exemplary orthogonal frequency division multiplexing (OFDM) wireless network **100**, which is capable of performing channel estimation according to the principles of the present disclosure. In the illustrated embodiment, wireless network **100** includes base station (BS) **101**, base station (BS) **102**, base station (BS) **103**, and other similar base stations (not shown). Base station **101** is in communication with base station **102** and base station **103**. Base station **101** is also in communication with Internet **130** or a similar IP-based network (not shown).

Base station **102** provides wireless broadband access (via base station **101**) to Internet **130** to a first plurality of subscriber stations within coverage area **120** of base station **102**. The first plurality of subscriber stations includes subscriber station **111**, which may be located in a small business (SB), subscriber station **112**, which may be located in an enterprise

(E), subscriber station **113**, which may be located in a WiFi hotspot (HS), subscriber station **114**, which may be located in a first residence (R), subscriber station **115**, which may be located in a second residence (R), and subscriber station **116**, which may be a mobile device (M), such as a cell phone, a wireless laptop, a wireless PDA, or the like.

Base station **103** provides wireless broadband access (via base station **101**) to Internet **130** to a second plurality of subscriber stations within coverage area **125** of base station **103**. The second plurality of subscriber stations includes subscriber station **115** and subscriber station **116**. In an exemplary embodiment, base stations **101-103** may communicate with each other and with subscriber stations **111-116** using OFDM or OFDMA techniques.

Base station **101** may be in communication with either a greater number or a lesser number of base stations. Furthermore, while only six subscriber stations are depicted in FIG. **1**, it is understood that wireless network **100** may provide wireless broadband access to additional subscriber stations. It is noted that subscriber station **115** and subscriber station **116** are located on the edges of both coverage area **120** and coverage area **125**. Subscriber station **115** and subscriber station **116** each communicate with both base station **102** and base station **103** and may be said to be operating in handoff mode, as known to those of skill in the art.

Subscriber stations **111-116** may access voice, data, video, video conferencing, and/or other broadband services via Internet **130**. In an exemplary embodiment, one or more of subscriber stations **111-116** may be associated with an access point (AP) of a WiFi WLAN. Subscriber station **116** may be any of a number of mobile devices, including a wireless-enabled laptop computer, personal data assistant, notebook, handheld device, or other wireless-enabled device. Subscriber stations **114** and **115** may be, for example, a wireless-enabled personal computer (PC), a laptop computer, a gateway, or another device.

FIG. **2A** is a high-level diagram of the transmit path in orthogonal frequency division multiplexing (OFDM) transmitter **200** according to an exemplary embodiment of the disclosure. FIG. **2B** is a high-level diagram of the receive path in orthogonal frequency division multiplexing (OFDM) receiver **260** according to an exemplary embodiment of the disclosure. OFDM transmitter **200** comprises quadrature amplitude modulation (QAM) modulator **205**, serial-to-parallel (S-to-P) block **210**, Inverse Fast Fourier Transform (IFFT) block **215**, parallel-to-serial (P-to-S) block **220**, add cyclic prefix block **225**, and OFDM symbol processing block **230**. OFDM receiver **250** comprises remove cyclic prefix block **260**, serial-to-parallel (S-to-P) block **265**, Fast Fourier Transform (FFT) block **270**, parallel-to-serial (P-to-S) block **275**, quadrature amplitude modulation (QAM) demodulator **280**, and channel estimation block **285**.

At least some of the components in FIGS. **2A** and **2B** may be implemented in software while other components may be implemented by configurable hardware or a mixture of software and configurable hardware. In particular, it is noted that the FFT blocks and the IFFT blocks described in FIGS. **2A** and **2B** may be implemented as configurable software algorithms, where the values of FFT and IFFT sizes may be modified according to the implementation.

QAM modulator **205** receives a stream of input data and modulates the input bits (or symbols) to produce a sequence of frequency-domain modulation symbols. Serial-to-parallel block **210** converts (i.e., de-multiplexes) the serial QAM symbols to parallel data to produce M parallel symbol streams where M is the IFFT/FFT size used in OFDM transmitter **200** and OFDM receiver **250**. IFFT block **215** then performs an IFFT operation on the M parallel symbol streams to produce time-domain output signals. Parallel-to-serial block **220** converts (i.e., multiplexes) the parallel time-domain output symbols from IFFT block **215** to produce a serial time-domain signal.

Add cyclic prefix block **225** then inserts a cyclic prefix to each OFDM symbol in the time-domain signal. As is well known, the cyclic prefix is generated by copying the last G samples of an N sample OFDM symbol and appending the copied G samples to the front of the OFDM symbol. Finally, OFDM symbol processing block **230** processes the incoming OFDM symbols as described in FIG. **3** and as described in U.S. patent application Ser. No. 11/327,799. The process OFDM samples at the output of OFDM symbol processing block **230** are then sent to up-conversion circuitry (not shown) prior to being transmitted from multiples transmit antennas.

The transmitted RF signal arrives at OFDM receiver **250** after passing through the wireless channel and reverse operations to those in OFDM transmitter **200** are performed. Remove cyclic prefix block **260** removes the cyclic prefix to produce the serial time-domain baseband signal. Serial-to-parallel block **265** converts the time-domain baseband signal to parallel time domain signals. FFT block **270** then performs an FFT algorithm to produce M parallel frequency-domain signals. Parallel-to-serial block **275** converts the parallel frequency-domain signals to a sequence of QAM data symbols. QAM demodulator **280** then demodulates the QAM symbols to recover the original input data stream. Channel estimation block **285** also receives the QAM data symbols from parallel-to-serial block **275** and performs channels estimation. As will be described below in greater detail, the channel estimation values are used to determine a parameter set of gain values and delay values that are used in OFDM symbol processing block **230** in OFDM transmitter **200** and are used by QAM demodulator **280** to demodulate the QAM data symbols.

The exemplary transmit path of OFDM transmitter **200** may be representative of the transmit paths of any one of base stations **101-103** or any one of subscriber stations **111-116**. Similarly, the exemplary receive path of OFDM receiver **250** may be representative of the transmit paths of any one of base stations **101-103** or any one of subscriber stations **111-116**. However, since multiple antenna configurations are more common in base stations than in subscriber stations or other mobile devices, for the sake of simplicity and clarity, the descriptions that follow will be directed toward transactions between a base station (e.g., BS **102**) that implements a transmit path similar to OFDM transmitter **200** and a subscriber station (e.g., SS **116**) that implements a receive path similar to OFDM receiver **250**. However, such an exemplary embodiment should not be construed to limit the scope of the present disclosure. It will be appreciated by those skilled in the art that in cases where multiple antennas are implemented in a subscriber station, the transmit path and the receiver path of both the base station and the subscriber station may be implemented as in shown in FIGS. **2A** and **2B**.

FIG. **3** illustrates OFDM symbol processing block **230** in greater detail according to an exemplary embodiment of the present disclosure. OFDM symbol processing block **230** comprises P delay elements, including exemplary delay elements **311** and **312**, P+1 amplifiers, including exemplary amplifiers **321**, **322** and **323**, and P+1 transmit antennas, including exemplary antennas **331**, **332** and **333**. Delay elements **311** and **312** are arbitrarily labeled "D1" and "DP", respectively. OFDM symbol processing block **230** receives incoming OFDM symbols and forwards P+1 copies of each OFDM symbol to the P+1 transmit antennas. Each OFDM symbol comprises N+G samples, where N is the number of

samples in the original data symbol and G is the number of samples in the cyclic prefix appended to the original symbol.

A first copy of each OFDM symbol is applied directly to the input of amplifier **321**, amplified by a gain value, g0, and sent to antenna **331**. A second copy of each OFDM symbol is delayed by delay element **311**, applied to the input of amplifier **322**, amplified by a gain value, g1, and sent to antenna **332**. Other copies of each OFDM symbol are similarly delayed and amplified according to the number of antennas. By way of example, the P+1 copy of each OFDM symbol is delayed by delay element **312**, applied to the input of amplifier **323**, amplified by a gain value, gP, and sent to antenna **333**. The gain values and the delay values are determined by the values in an OFDM symbol processing parameter set, as described hereafter and in U.S. patent application Ser. No. 11/327,799. The result is that multiple copies of each OFDM are transmitted, wherein each copy of an OFDM symbol is amplified by a selected amount and delayed by a selected amount relative to other OFDM symbol copies. U.S. patent application Ser. No. 11/327,799, incorporated by reference above, describes a number of architectures for OFDM symbol processing block **230** that achieve such a result. In an advantageous embodiment, the delays introduced by OFDM symbol processing block **230** are cyclic delays, as disclosed in U.S. patent application Ser. No. 11/327,799.

FIG. **4**A illustrates data traffic transmitted in the downlink from base station **102** to subscriber station **116** according to an exemplary embodiment of the present disclosure. An exemplary frame of OFDM data is 10 milliseconds in length and comprises fifteen (15) transmit time intervals (TTIs), namely TTI 1 through TTI 15, where each one of TTI 1 through TTI 15 is 0.667 milliseconds in duration. Within each of TTI 2 through TTI 15, there are four OFDM data symbols, where each OFDM data symbol is 0.1667 milliseconds in duration. In the first TTI, namely TTI 1, there are three OFDM data symbols that are preceded by a pilot preamble symbol. The pilot preamble symbol is used by SS **116** to perform synchronization channel estimation and to determine the OFDM symbol processing parameter set.

FIG. **4**B is a flow diagram illustrating the determination of the user channel type based on the measurements on the preamble according to an exemplary embodiment of the disclosure. In an OFDM system, a known pilot sequence is transmitted for one or more OFDM symbol durations. Channel estimation block **285** in the receiver (i.e., SS **116**) detects the known pilot signal, which is then use to perform synchronization (process step **410**). Channel estimation block **285** uses the detected preamble symbols to determine the degree of multipath effects in the channel and, therefore, the frequency selectivity in the channel between BS **102** and SS **116** (process step **420**).

Based on the profile of the channel, channel estimation block **285** (or another processing element or controller in SS **116**) determines (i.e., calculates) a set of OFDM symbol processing parameters (i.e., gain values and delay values) that may be used in BS **102** to improve reception of OFDM symbols in SS **116** (process step **430**). SS **116** then feeds back the OFDM symbol processing parameter set to BS **102** in the uplink (process step **440**). Other factors, such as mobile speed, can also be used in determining (or calculating) the OFDM symbol processing parameters. The channel type may also be determined by using other mechanisms, such as reference in time-frequency.

In this manner, BS **102** receives an OFDM symbol processing parameter set from each subscriber station. Thereafter, as BS **102** schedules each subscriber station to receive data, BS **102** uses the OFDM symbol processing parameter set for that subscriber station to modify the OFDM symbols transmitted from each antenna for BS **102**. For example, BS **102** may use OFDM Symbol Processing Parameter Set A to transmit OFDM symbols from two or more antennas to SS **116** and may use OFDM Symbol Processing Parameter Set B to simultaneously transmit OFDM symbols from two or more antennas to SS **115**.

FIG. **5** is a message flow diagram illustrating the transmission of OFDM symbols from base station **102** to subscriber station **116** according to one embodiment of the disclosure. In this example, base station **102** uses two transmit antennas (first antenna ANT1 and second antenna ANT 2) to transmit to SS **116**. SS **116** receives a first pilot signal (Pilot1) from antenna ANT1 and receives a second pilot signal (Pilot2) from antenna ANT 2. SS A then determines OFDM Symbol Processing Parameter Set A as described above in FIGS. **4**A and **4**B.

Next, SS **116** transmits OFDM Symbol Processing Parameter Set A to BS **102** in signal **505**. Thereafter, BS **102** uses OFDM Symbol Processing Parameter Set A to transmit OFDM data symbols in the downlink back to SS **116**. As noted above, the OFDM symbol processing parameters in Parameter Set A consist of symbol delays and gains from the two antennas. By way of example, in signal **520**, BS **102** transmits from ANT1 processed OFDM symbols that were processed using Parameter Set A. In signal **525**, BS **102** simultaneously transmits from ANT2 processed OFDM symbols that were processed using Parameter Set A.

BS **102** also simultaneously transmits pilot signal **510** (Pilot1) and pilot signal **515** (Pilot2) from the two transmit antennas, ANT 1 and ANT 2. In the embodiment in FIG. **5**, Pilot1 and Pilot2 are not processed using the parameters in OFDM Symbol Processing Parameter Set A. This is due to the fact that another transmission may be scheduled at the same time for another subscriber station on other OFDM subcarriers using a different set of OFDM symbol processing parameters. The pilot signals must be correctly understood by all the subscriber stations scheduled in the cell, so the pilot signals are not modified using OFDM Symbol Processing Parameter Set A.

FIG. **6** is a flow diagram illustrating the processing of pilot signals and OFDM data symbols according to an exemplary embodiment of the present disclosure. Because the OFDM symbols in signals **520** and **525** are processed using the values in OFDM Symbol Processing Parameter Set A, signals **520** and **525** are combined during transmission over the radio link in such a way that single OFDM symbols are received in SS **116** from BS **102** (process step **660**). Since pilot signals **510** and **515** (Pilot1 and Pilot2) are transmitted on orthogonal subcarriers from antenna ANT1 and antenna ANT2, pilot signals **510** and **515** are received separately at SS **116** (process steps **605** and **610**).

In order to get correct channel estimation for demodulation, SS **116** compensates pilot signals **510** and **515** (Pilot1 and Pilot2) from antennas ANT1 and ANT2 using the Parameter Set A received from channel estimation block **285** (process steps **615** and **620**). Compensated pilot signals **510** and **515** are then combined (process step **630**) and the overall channel estimate is obtained (process step **640**). This overall channel estimate is then used by demodulator **280** to demodulate the processed data symbols carried in the OFDM subcarriers (process step **660**).

FIG. **7** is a message flow diagram illustrating the transmission of OFDM symbols from base station **102** to subscriber station **116** according to another embodiment of the disclosure. In FIG. **7**, the OFDM symbol processing parameters are determined in base station (BS) **102**, rather than in subscriber

station (SS) **116**. BS **102** may determine (or estimate) the OFDM symbol processing parameters in Parameter Set A from a number of different uplink signals **705** transmitted by SS **116**, including pilot signals **705**, preamble signals **705** and/or data signals **705** from SS **116**.

In this example, since Pilot1 signal **710** and Pilot2 signal **715** are not processed using Parameter Set A, BS **101** transmits OFDM Symbol Processing Parameter Set A to SS **116** in control message **720**. SS **116** then uses the OFDM symbol processing parameters as described in FIGS. **2-6**. BS **102** transmits processed OFDM symbols **725** from ANT1 and processed symbols **720** from ANT2 using the gain and delay values in Parameter Set A. SS **116** uses the same gain and delay parameters in control message **720** to compensate the pilots and to perform the overall channel estimation for data demodulation.

FIG. **8** is a message flow diagram illustrating the transmission of OFDM symbols from base station **102** to subscriber station **116** according to another embodiment of the disclosure. Similar to FIG. **7**, the OFDM symbol processing parameters in FIG. **8** are again determined in base station (BS) **102** for the case of two transmit antennas, rather than in subscriber station (SS) **116**. BS **102** may determine (or estimate) the OFDM symbol processing parameters in Parameter Set A from a number of different uplink signals **805** transmitted by SS **116**, including pilot signals **805**, preamble signals **805** and/or data signals **805** from SS **116**.

However, unlike FIG. **7**, Pilot1 signal **810** from ANT1 and Pilot2 signal **815** from ANT2 are processed using Parameter Set A. In this case, the Pilot1 signal and the Pilot2 signal both use the same OFDM subcarriers. In other words, the two pilots are not transmitted on orthogonal subcarriers. Therefore, the Pilot1 signal and the Pilot2 signal are received in SS **116** as a single signal that can be directly used for overall channel estimation. The channel estimates are then used for data demodulation. BS **102** also transmits processed OFDM symbols **825** from ANT1 and processed symbols **820** from ANT2 using the gain and delay values in Parameter Set A.

In a scenario where the Pilot1 signal and the Pilot2 signal are not compensated, the channel quality estimate is based on the pilot signal strengths SS **116** receives from the two transmit antennas, ANT1 and ANT2. SS **116** compensates the Pilot1 signal and the Pilot2 signal using the OFDM symbol processing parameters. This gives an estimate of the expected channel quality when BS **102** transmits OFDM symbols using the OFDM symbol processing parameters for SS **116**. SS **116** then transmits a channel quality estimate (CQE) message back to BS **102**. BS **102** determines an optimum data rate based on the channel quality estimate (CQE) message from SS **116** and then transmits processed OFDM symbols at that data rate.

In SS **116**, processed OFDM symbols containing data are processed using gain g0 from ANT1, gain g1 from ANT2 and delay D1 from ANT 2. These operations reverse the operations in OFDM symbol processing block **230** in FIG. **3**, assuming only transmit antenna **331** (i.e., ANT1) and transmits antenna **332** (i.e., ANT2) are used. In SS **116**, an FFT operation is performed on the received OFDM symbols in order to retrieve the information in the frequency domain. The data and pilot symbols carried on orthogonal subcarriers are separated in the frequency domain. The pilot signals are converted back to the time domain by performing an IFFT operation. In this process, the subcarriers carrying data are set to 0. Also, when an ANT1 OFDM symbol is generated, the subcarriers carrying ANT2 OFDM symbols are set to 0. Similarly, when an ANT2 OFDM symbol is generated, the subcarriers carrying the ANT1 OFDM symbols are set to 0.

SS **116** multiplies the pilot OFDM symbols from ANT1 with gain g0 and the pilot OFDM symbols from ANT2 with gain g1. The receiver also delays the pilots from ANT2 with delay D1. Again, these operations reverse the operations in OFDM symbol processing block **230** in FIG. **3**, assuming only transmit antenna **331** (i.e., ANT1) and transmits antenna **332** (i.e., ANT2) are used. The two resulting pilots are then combined to get the overall pilot. An FFT operation is performed on the overall pilot to get the overall channel response in the frequency domain. The channel estimate in the frequency domain is then used for data demodulation in the frequency domain. This additional compensation on the pilot signals allows for estimation of the additional processing done in BS **102** on the OFDM symbols containing data. The effect of the actual radio channel is also reflected in the overall channel estimate because the received pilot signals travel via the radio channel.

The compensation needs to be done on the pilot symbols only, and not the data symbols, because the data symbols are already processed in BS **102**. In an OFDM system, the pilot and data symbols are carried on OFDM subcarriers. Therefore, the compensation can either be done on the time domain OFDM symbol or directly in the frequency domain. In order to do compensation in the frequency domain, the affect of OFDM symbol delay in the time-domain must be accounted for in the frequency domain. In general, a time delay in the time domain translates into a phase rotation in the frequency domain. Therefore, the OFDM subcarriers carrying the pilot symbols may be appropriately phase rotated in the frequency domain to account for time delays.

While several embodiments have been provided in the present disclosure, it should be understood that the disclosed systems and methods may be embodied in many other specific forms without departing from the spirit or scope of the present disclosure. The exemplary embodiments disclosed are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. It is intended that the disclosure encompass all alternate forms within the scope of the appended claims along with their full scope of equivalents.

What is claimed is:

**1**. A method, comprising:

receiving an uplink signal;

determining a processing parameter for transmission of data on two antenna ports, the processing parameter including at least one of a time delay, a phase rotation and a gain based on the received uplink signal;

transmitting a first pilot and a second pilot; and

transmitting a first data symbol and a second data symbol on two antenna ports, at least one of the first data symbol and the second data symbol being processed based on the processing parameter.

**2**. The method of claim **1**, wherein the first pilot and the second pilot are generated independently of the processing parameter, and wherein the processing parameter is a symbol processing parameter.

**3**. The method of claim **1**, wherein the processing parameter is determined on a user-by-user basis.

**4**. The method of claim **1**, wherein the time delay is in a time domain and the phase rotation is in a frequency domain.

**5**. The method of claim **1**, wherein the uplink signal comprises at least one of an orthogonal frequency division multiplexing (OFDM) symbol processing parameter, an uplink pilot, and a preamble.

**6**. A method, comprising:

receiving a processing parameter for transmission of data on two antenna ports, the processing parameter includ-

ing at least one of a time delay, a phase rotation and a gain determined based on a received uplink signal;

receiving a first pilot, a second pilot, a first data symbol and a second data symbol transmitted on the two antenna ports; and

demodulating the first data symbol and the second data symbol based on the processing parameter, the first pilot and the second pilot.

7. The method of claim 6, wherein the first pilot and the second pilot are generated independently of the symbol processing parameter.

8. The method of claim 6, wherein the processing parameter is determined on a user-by-user basis.

9. The method of claim 6, wherein the time delay is in a time domain and the phase rotation is in a frequency domain.

10. The method of claim 6, wherein the demodulating further comprises:

estimating a channel using the first pilot, the second pilot and the processing parameter; and

demodulating the first and second data based on the estimated channel.

* * * * *

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United States Patent and Trademark Office

April 18, 2019

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U.S. PATENT: *8,102,833*
ISSUE DATE: *January 24, 2012*

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Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

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**PX 0006**
2:19-cv-00066-JRG

US008102833B2

(12) **United States Patent**
**Lee et al.**

(10) **Patent No.: US 8,102,833 B2**
(45) **Date of Patent: Jan. 24, 2012**

(54) **METHOD FOR TRANSMITTING UPLINK SIGNALS**


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(73) Assignee: **LG Electroics Inc.**, Seoul (KR)



( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 725 days.

(21) Appl. No.: **12/209,136**

(22) Filed: **Sep. 11, 2008**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 15, 2008 (KR) ........................ 10-2008-0068634

(51) **Int. Cl.**
***H04B 7/208*** (2006.01)

(52) **U.S. Cl.** ........................................ **370/344**; 370/319

(58) **Field of Classification Search** .................. 370/206, 370/278, 344, 208, 252, 294, 295, 315, 319, 370/328, 329, 330, 335, 336, 338; 455/450, 455/509

See application file for complete search history.



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| EP | 1811701 | 7/2007 |
| KR | 10-2004-0056976 | 7/2004 |
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*Assistant Examiner* — Mang Yeung
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey


(57) **ABSTRACT**

A method for transmitting uplink signals, which include ACK/NACK signals, control signals other than the ACK/NACK signals, and data signals, is disclosed. The method comprises serially multiplexing the control signals and the data signals; sequentially mapping the multiplexed signals within a specific resource region in accordance with a time-first mapping method, the specific resource region including a plurality of symbols and a plurality of virtual subcarriers; and arranging the ACK/NACK signals at both symbols near symbols to which a reference signal of the plurality of symbols is transmitted. Thus, the uplink signals can be transmitted to improve receiving reliability of signals having high priority.


**14 Claims, 9 Drawing Sheets**

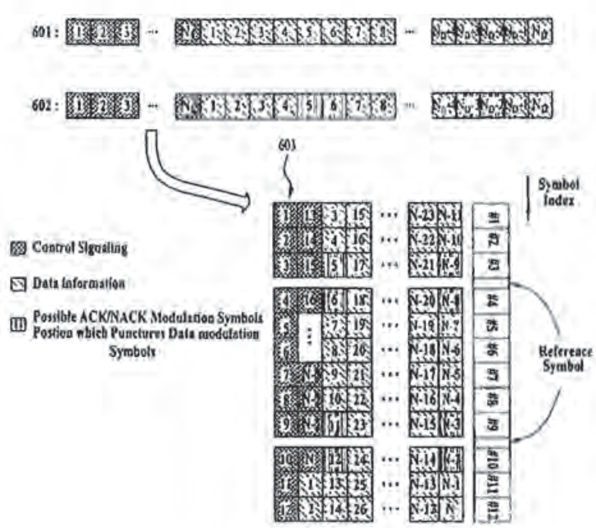


FIG. 1

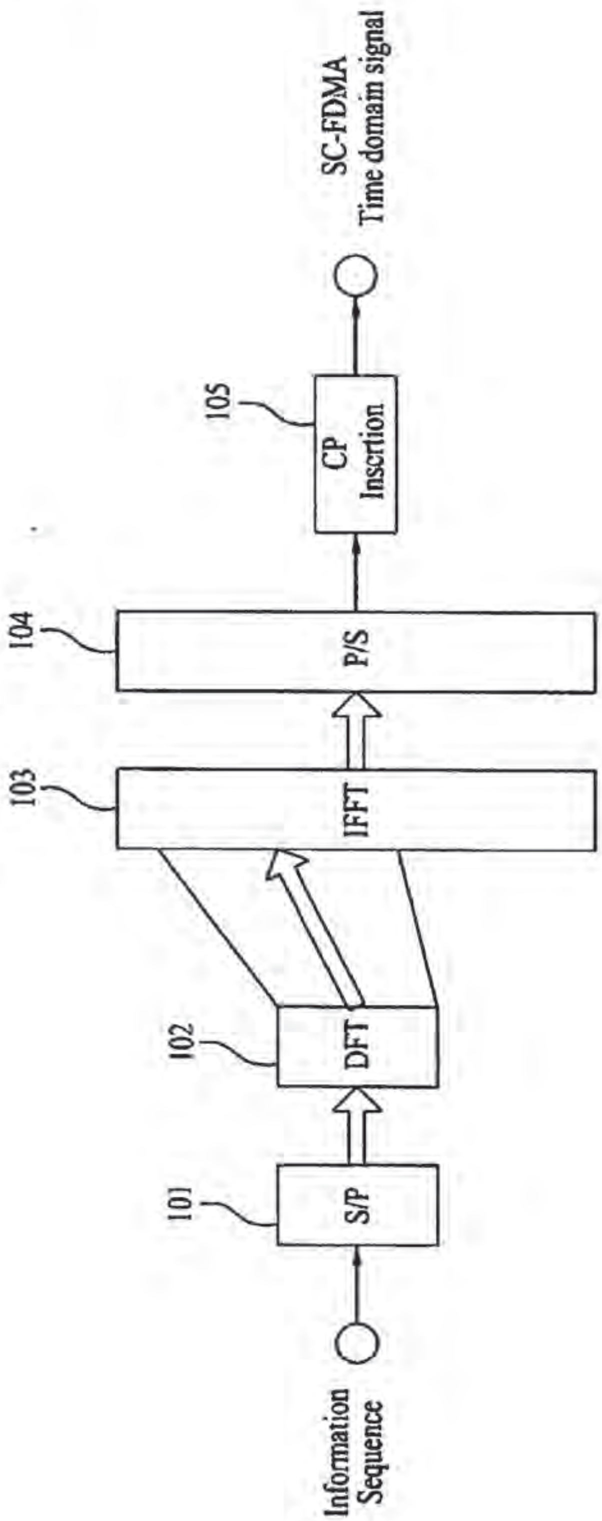

Information Sequence
101
S/P
102
DFT
103
IFFT
104
P/S
105
CP Insertion
SC-FDMA
Time domain signal

FIG. 2

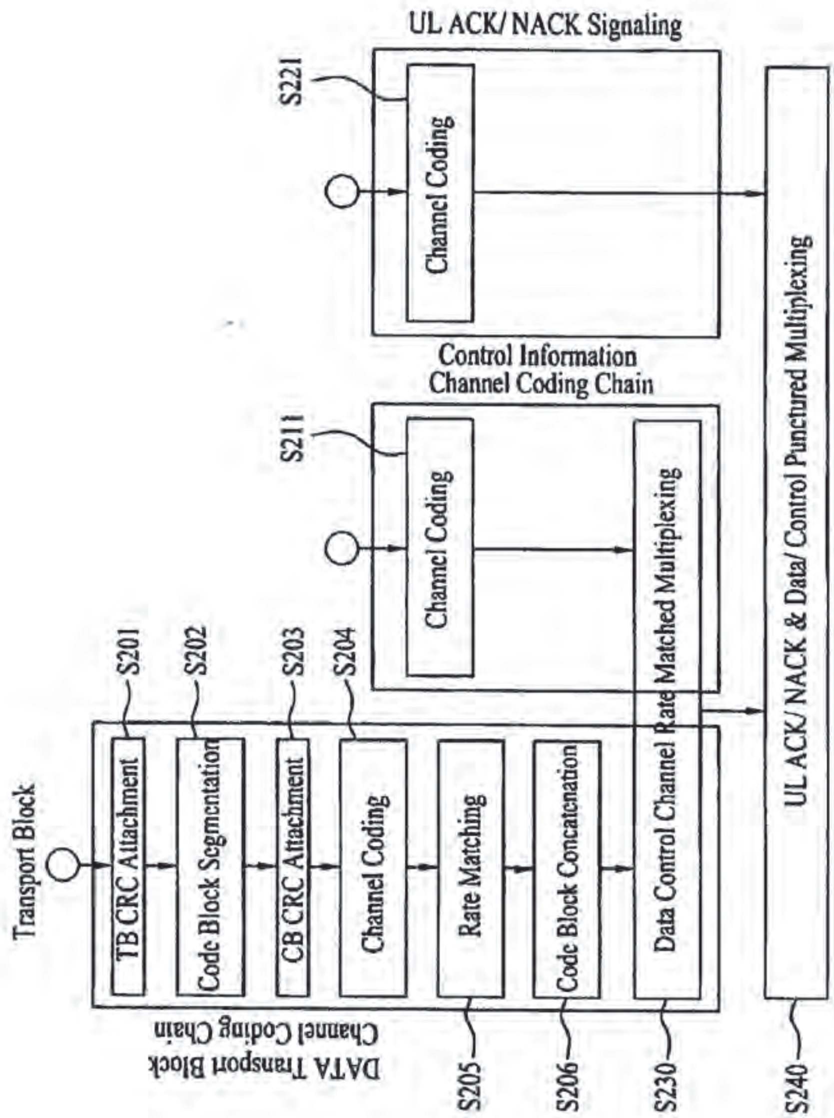

Transport Block
TB CRC Attachment
Code Block Segmentation
CB CRC Attachment
Channel Coding
Rate Matching
Code Block Concatenation
Data Control Channel Rate Matched Multiplexing
DATA Transport Block Channel Coding Chain
S201
S202
S203
S204
S205
S206
S230
S211
Channel Coding
Control Information Channel Coding Chain
S221
Channel Coding
UL ACK/ NACK Signaling
UL ACK/ NACK & Data/ Control Punctured Multiplexing
S240

FIG. 3

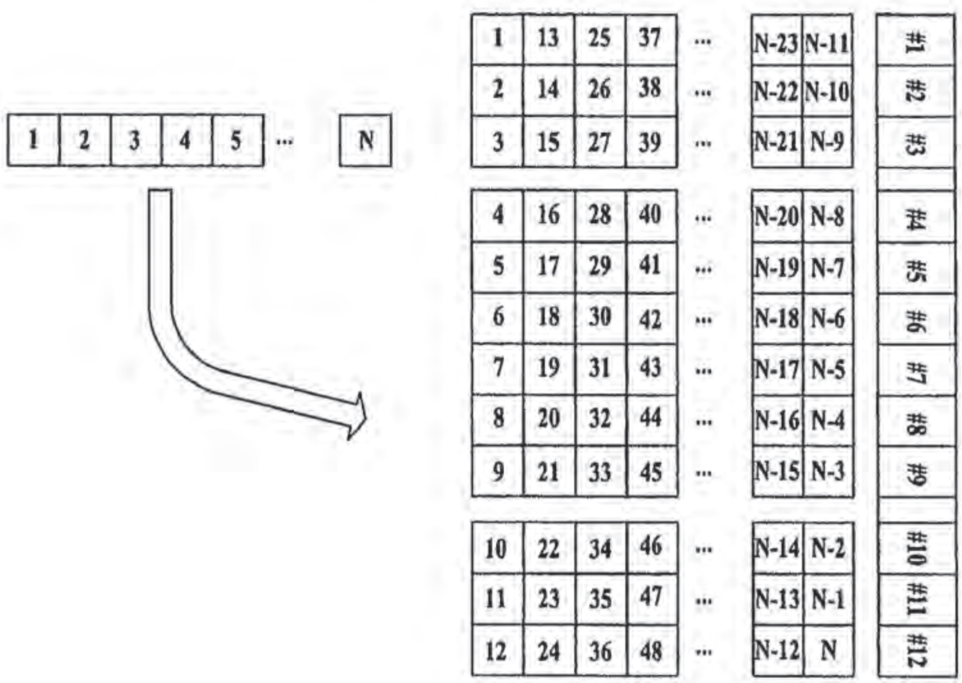

1 2 3 4 5 ... N
1 13 25 37 ... N-23 N-11 #1
2 14 26 38 ... N-22 N-10 #2
3 15 27 39 ... N-21 N-9 #3
4 16 28 40 ... N-20 N-8 #4
5 17 29 41 ... N-19 N-7 #5
6 18 30 42 ... N-18 N-6 #6
7 19 31 43 ... N-17 N-5 #7
8 20 32 44 ... N-16 N-4 #8
9 21 33 45 ... N-15 N-3 #9
10 22 34 46 ... N-14 N-2 #10
11 23 35 47 ... N-13 N-1 #11
12 24 36 48 ... N-12 N #12

FIG. 4

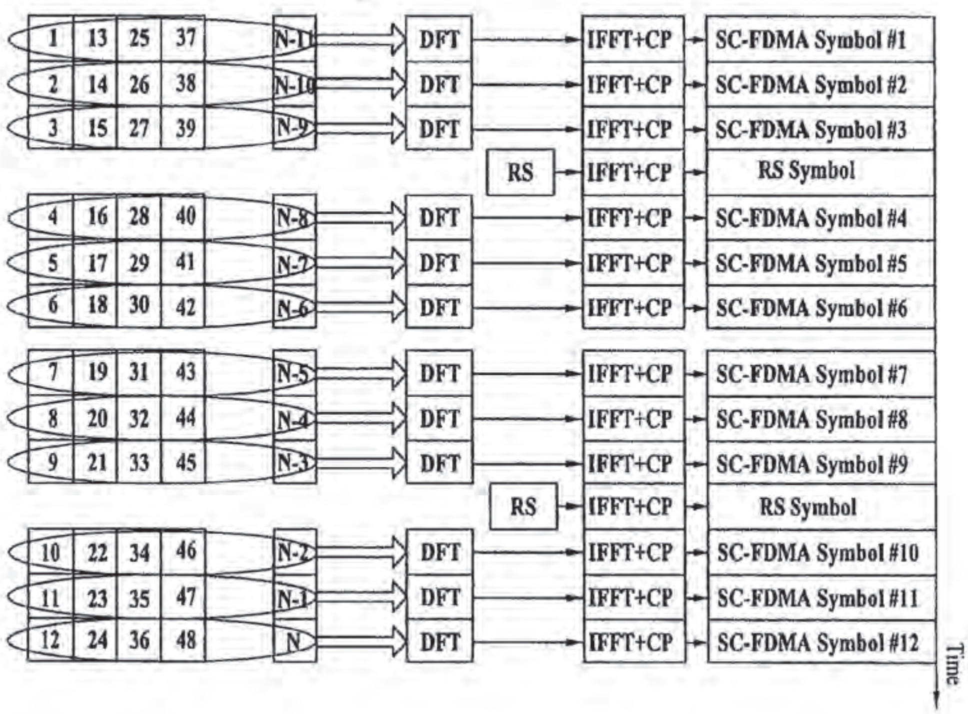

1 13 25 37
2 14 26 38
3 15 27 39
4 16 28 40
5 17 29 41
6 18 30 42
7 19 31 43
8 20 32 44
9 21 33 45
10 22 34 46
11 23 35 47
12 24 36 48
N-11
N-10
N-9
N-8
N-7
N-6
N-5
N-4
N-3
N-2
N-1
N
DFT
RS
IFFT+CP
SC-FDMA Symbol #1
SC-FDMA Symbol #2
SC-FDMA Symbol #3
RS Symbol
SC-FDMA Symbol #4
SC-FDMA Symbol #5
SC-FDMA Symbol #6
SC-FDMA Symbol #7
SC-FDMA Symbol #8
SC-FDMA Symbol #9
RS Symbol
SC-FDMA Symbol #10
SC-FDMA Symbol #11
SC-FDMA Symbol #12
Time

FIG. 5

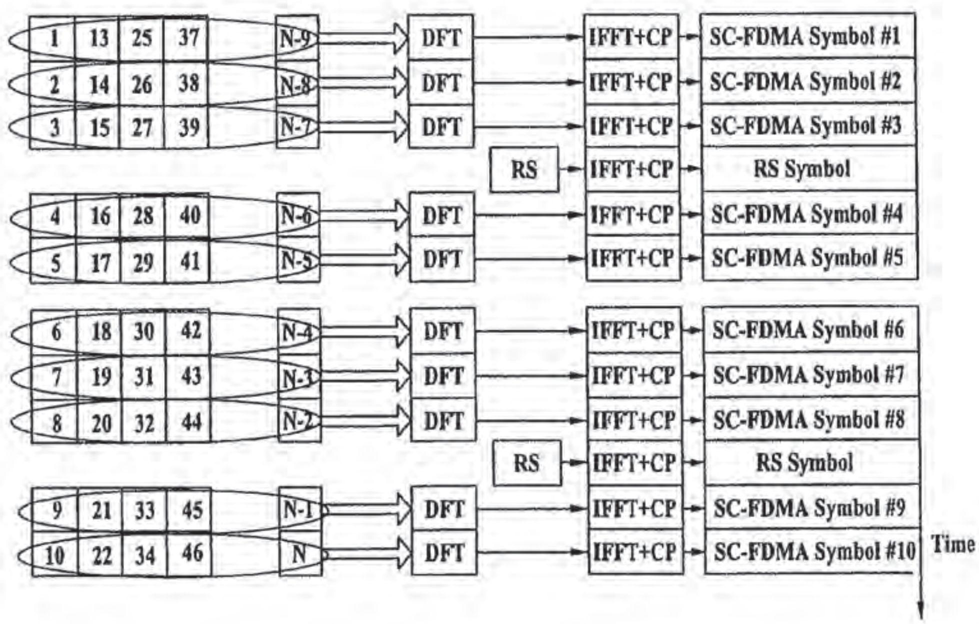

1 13 25 37 N-9 DFT IFFT+CP SC-FDMA Symbol #1
2 14 26 38 N-8 DFT IFFT+CP SC-FDMA Symbol #2
3 15 27 39 N-7 DFT IFFT+CP SC-FDMA Symbol #3
RS IFFT+CP RS Symbol
4 16 28 40 N-6 DFT IFFT+CP SC-FDMA Symbol #4
5 17 29 41 N-5 DFT IFFT+CP SC-FDMA Symbol #5
6 18 30 42 N-4 DFT IFFT+CP SC-FDMA Symbol #6
7 19 31 43 N-3 DFT IFFT+CP SC-FDMA Symbol #7
8 20 32 44 N-2 DFT IFFT+CP SC-FDMA Symbol #8
RS IFFT+CP RS Symbol
9 21 33 45 N-1 DFT IFFT+CP SC-FDMA Symbol #9
10 22 34 46 N DFT IFFT+CP SC-FDMA Symbol #10
Time

FIG. 6

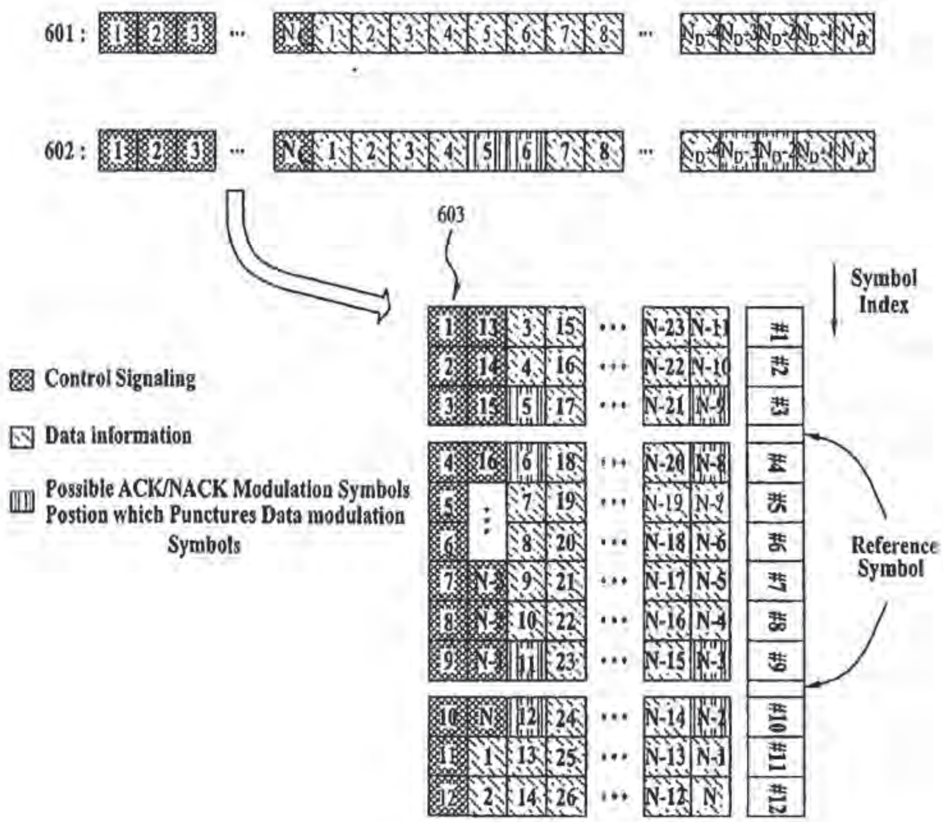

601 :
602 :
603
Symbol Index
Control Signaling
Data information
Possible ACK/NACK Modulation Symbols Postion which Punctures Data modulation Symbols
Reference Symbol
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12

FIG. 7

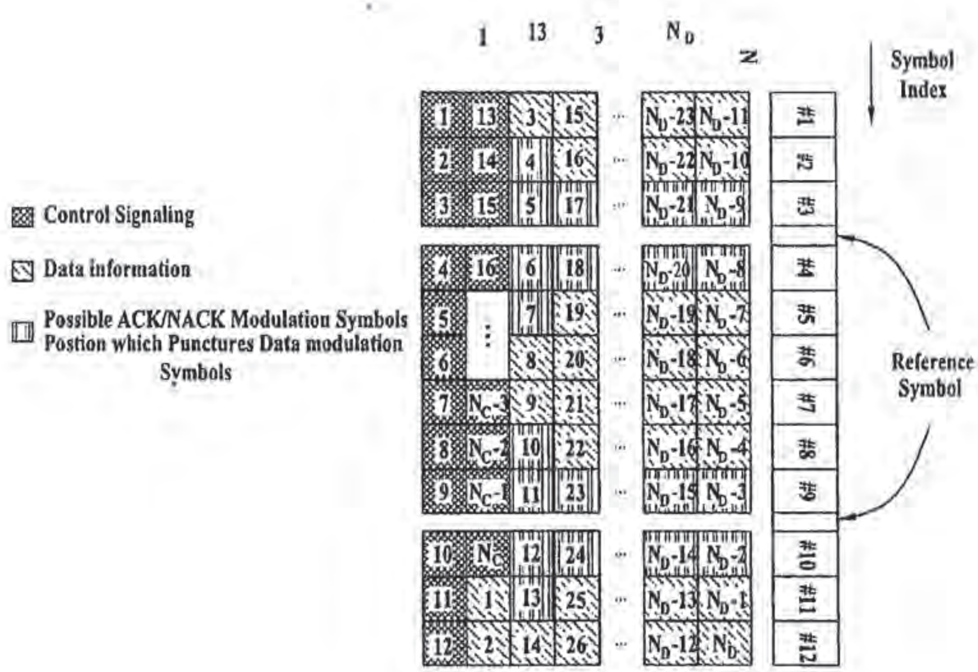

Control Signaling
Data information
Possible ACK/NACK Modulation Symbols Postion which Punctures Data modulation Symbols
Symbol Index
Reference Symbol
1
13
3
$N_D$
N
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12

FIG. 8

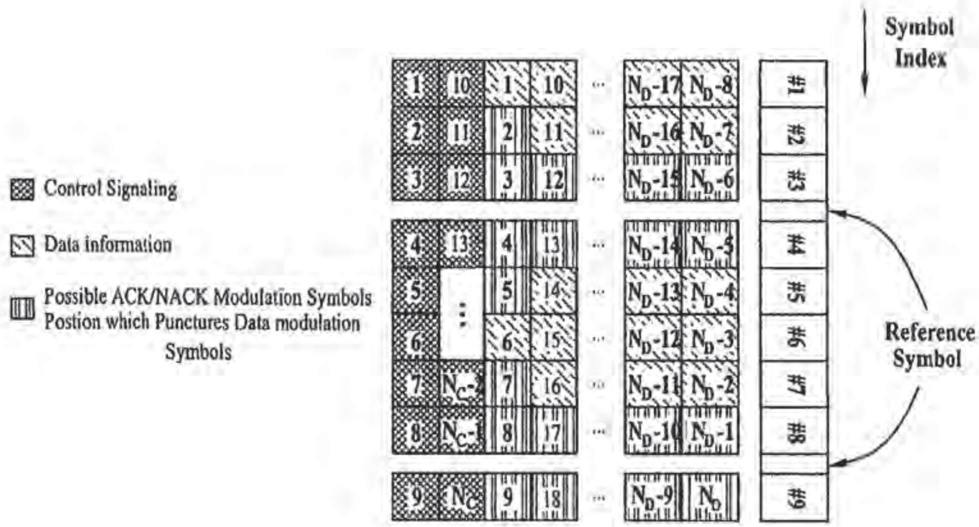
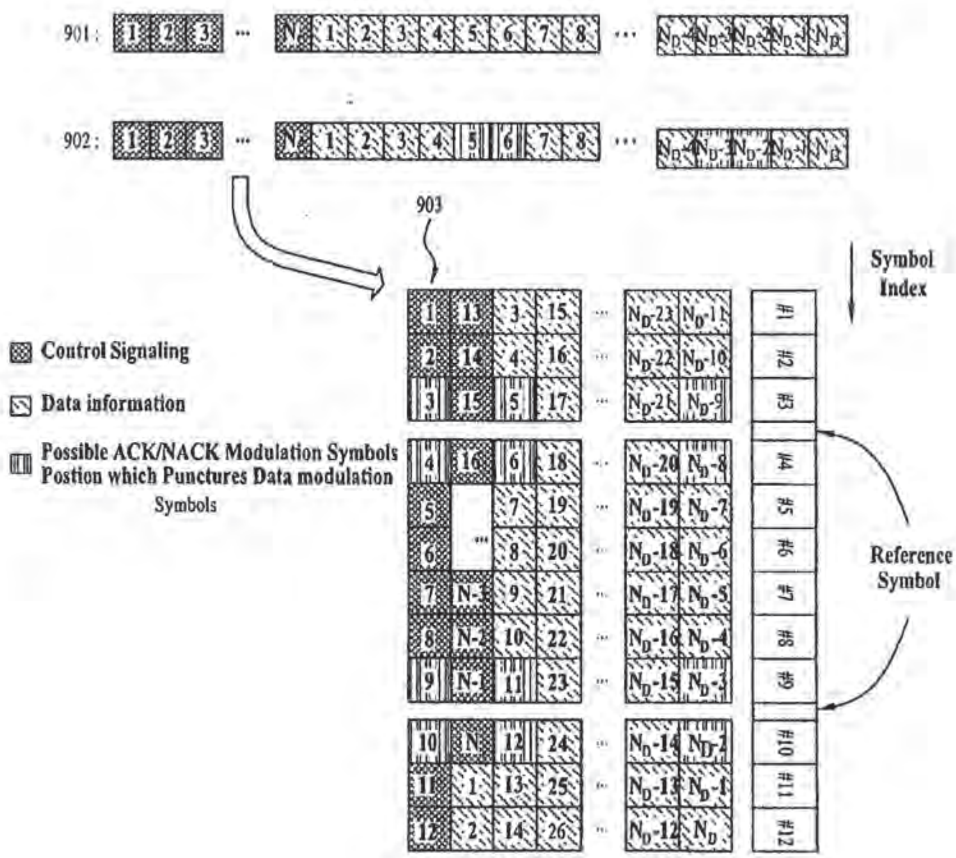

Control Signaling
Data information
Possible ACK/NACK Modulation Symbols Postion which Punctures Data modulation Symbols
Symbol Index
Reference Symbol
#1
#2
#3
#4
#5
#6
#7
#8
#9

FIG. 9


901 :
902 :
903
Control Signaling
Data information
Possible ACK/NACK Modulation Symbols Postion which Punctures Data modulation Symbols
Symbol Index
Reference Symbol
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12

# METHOD FOR TRANSMITTING UPLINK SIGNALS

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of the Korean Patent Application No. 10-2008-0068634, filed on Jul. 15, 2008, which is hereby incorporated by reference as if fully set forth herein.

This application also claims the benefit of U.S. Provisional Application Ser. Nos. 60/972,244, filed on Sep. 13, 2007, 60/987,427, filed on Nov. 13, 2007 and 60/988,433, filed on Nov. 16, 2007, the contents of which are hereby incorporated by reference herein in their entirety.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to mobile communication technology, and more particularly, to technology of transmitting uplink signals including ACK/NACK signals, control signals other than the ACK/NACK signals, and data signals.

2. Discussion of the Related Art

A user equipment (UE) of a mobile communication system transmits various signals through an uplink. Uplink signals transmitted by the user equipment can be segmented into data signals and control signals. Also, examples of the control signals transmitted to the uplink include uplink ACK/NACK signals for HARQ communication, channel quality indicator (CQI) information, and preceding matrix index (PMI).

3GPP LTE system uses a single carrier frequency division multiplexing access (SC-FDMA) scheme for uplink signal transmission. Also, the 3GPP LTE system prescribes that data signals and control signals among the uplink signals are first multiplexed and ACK/NACK signals are transmitted to the multiplexed signals by puncturing the data or control signals when uplink ACK/NACK signal transmission is required for downlink data. Hereinafter, in order that the ACK/NACK signals are divided from control signals other than the ACK/NACK signals, the control signals will mean those except for the ACK/NACK signals.

Meanwhile, Athens conference (#50) for 3GPP LTE has decided that data information is rate matched together with control information when the control information is multiplexed with the data information, wherein the control information is transmitted near a reference signal. This is to improve channel estimation performance by approximating all the control signals to the reference signal as the control signals generally require higher reliability than the data signals.

However, the control signals transmitted to the uplink include various signals as described above, and the ACK/NACK signals require higher reliability than the other control signals. In this case, when uplink ACK/NACK signal transmission is required while all the control signals are transmitted by approximating to the reference signal, problems occur in that the ACK/NACK signals can neither be transmitted by puncturing the control signals arranged near the reference signal nor be transmitted near the reference signal.

In this respect, a technology of transmitting uplink signals by efficiently arranging ACK/NACK signals and other control signals in a resource region considering priority among them is required.

## SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a method for transmitting uplink signals, which substantially obviates one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method for transmitting uplink signals by efficiently arranging ACK/NACK signals and other control signals in a resource region considering priority among them.

Another object of the present invention is to provide transmitting uplink signals using the aforementioned signal arrangement.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, the present invention provides a method for transmitting uplink signals, which include ACK/NACK signals, control signals other than the ACK/NACK signals, and data signals. The method comprises serially multiplexing the control signals and the data signals; sequentially mapping the multiplexed signals within a specific resource region in accordance with a time-first mapping method, the specific resource region including a plurality of symbols and a plurality of virtual subcarriers; and arranging the ACK/NACK signals at both symbols near to symbols through which a reference signal is transmitted.

At this time, the ACK/NACK signals are overwritten on a part of the multiplexed signals. And, the part of the multiplexed signals, on which the ACK/NACK signals are overwritten, includes one or more of the control signals and the data signals.

Also, the method further comprises performing a discrete fourier transform (DFT) for the signals mapped on the specific resource region in a unit of each symbols of the plurality of symbols in accordance with each index of the plurality of virtual subcarriers; performing an inverse fast fourier transform (IFFT) for the DFT symbol unit signals and attaching a cyclic prefix (CP) the signals; and transmitting the symbol unit signals attached with the CP as single carrier frequency division multiplexing access (SC-FDMA) symbols.

Also, the method further comprises transmitting the signals mapped on the specific resource region through a physical uplink sharing channel (PUSCH).

In another aspect of the present invention, the present invention provides a method for transmitting uplink signals, which include ACK/NACK signals, control signals other than the ACK/NACK signals, and data signals. The method comprises performing channel coding for each of the data signals, the control signals, and the ACK/NACK signals; serially multiplexing the channel coded data and control signals; sequentially mapping the multiplexed signals in accordance with a time-first mapping method within a specific resource region in accordance with a time-first mapping method, the specific resource region including a plurality of symbols and a plurality of virtual subcarriers; and arranging the ACK/NACK signals at both symbols near to the symbols through which a reference signal is transmitted.

At this time, the step of performing channel coding for the data signals includes attaching a CRC for a transport block (TB) to a transport block for transmission of the data signals; segmenting the transport block attached with the CRC for the transport block in a code block unit and attaching a CRC for a code block to the segmented code block; performing channel coding for the data attached with the CRC for a code block; and performing rate matching and code block concatenation for the channel coded data.

According to the aforementioned embodiments of the present invention, it is possible to transmit uplink signals by efficiently arranging ACK/NACK signals and other control signals in a resource region in accordance with priority among them.

In addition, the ACK/NACK signals having high priority can be set in such a manner that they acquire more channel estimation effect.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIG. **1** is a block diagram illustrating a transmitter to describe a method for transmitting signals in accordance with a single carrier frequency division multiplexing access (SC-FDMA) scheme;

FIG. **2** is a diagram illustrating a procedure of multiplexing data information, control information and ACK/NACK signals for uplink signal transmission;

FIG. **3** is a diagram illustrating an example of mapping information sequences according to one embodiment of the present invention in accordance with a time-first mapping method

FIG. **4** and FIG. **5** are diagrams illustrating a method for transmitting information, which is mapped in accordance with the time-first mapping method as illustrated in FIG. **3**, in accordance with the SC-FDMA scheme;

FIG. **6** is a diagram illustrating a method for transmitting uplink signals in accordance with one embodiment of the present invention;

FIG. **7** and FIG. **8** are diagrams illustrating a method for processing a number of ACK/NACK information data to be transmitted in accordance with one embodiment of the present invention; and

FIG. **9** is a diagram illustrating that ACK/NACK signals are inserted by puncturing the control signals as well as the data signals in accordance with another embodiment of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, the preferred embodiments of the present invention will be described with reference to the accompanying drawings. It is to be understood that the detailed description, which will be disclosed along with the accompanying drawings, is intended to describe the exemplary embodiments of the present invention, and is not intended to describe a unique embodiment with which the present invention can be carried out. Hereinafter, the following detailed description includes detailed matters to provide full understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention can be carried out without the detailed matters.

Meanwhile, in some cases, to prevent the concept of the present invention from being ambiguous, structures and apparatuses of the known art will be omitted, or will be shown in the form of a block diagram based on main functions of each structure and apparatus. Also, wherever possible, the same reference numbers will be used throughout the drawings and the specification to refer to the same or like parts.

As described above, the embodiment of the present invention is intended to provide a method for transmitting uplink signals by efficiently arranging ACK/NACK signals and other control signals in a resource region considering priority among them. To this end, a detailed method for transmitting uplink signals in a 3GPP LTE system will be described.

FIG. **1** is a block diagram illustrating a transmitter to describe a method for transmitting signals in accordance with a single carrier frequency division multiplexing access (SC-FDMA) scheme.

As described above, a 3GPP LTE system transmits uplink signals in accordance with a single carrier frequency division multiplexing access (SC-FDMA) scheme. In detail, direct-to-parallel conversion is performed for information sequences to be transmitted, to perform a discrete fourier transform (DFT) (**101**). The DFT is performed for the signals converted to the parallel sequences (**102**), and then inverse fast fourier transform (IFFT) can be performed to obtain a single carrier feature (**103**). At this time, a length of information inserted to an IFFT module **103** may not be equal to a size of the IFFT module **103**. However, it is required that the DFT result performed by the DFT module **102** should be mapped with continuous IFFT input indexes.

Values undergone IFFT are again converted to serial signals by a parallel-to-serial conversion module **104**. Afterwards, the signals are changed to a format of OFDM symbols by a cyclic prefix (CP) (**105**) and then transmitted to a real time space.

The aforementioned SC-FDMA scheme has advantages in that it has low peak power-to-average power ratio (PAPR) and/or cubic metric (CM) while maintaining a single carrier feature. However, in order to satisfy low PAPR/CM condition while maintaining a single carrier feature, it is required that information undergone DFT preceding should be input to the IFFT module **103** in an OFDM format by mapping with continuous indexes. In other words, it is required that DFT precoded information should be inserted to continuous subcarriers of OFDM. Accordingly, it is preferable that information data (for example, control information and data information) having different features are multiplexed together when they are transmitted to an uplink so that they undergo DFT precoding together and then are transmitted in an OFDM format.

Hereinafter, a procedure of multiplexing data information and control information will be described.

FIG. **2** is a diagram illustrating a procedure of multiplexing data information, control information and ACK/NACK signals for uplink signal transmission.

Data information multiplexed with control information is segmented into several code blocks (CB) in accordance with a size of a transport block (TB) to be transmitted to the uplink after CRC for TB is attached to the TB (S**201** and S**202**). Afterwards, the CRC for CB is attached to several CBs (S**203**), and channel coding is performed for the result value obtained by attaching the CRC for CB to several CBs (S**204**). Also, after the channel coded data undergo rate matching (S**205**), concatenation among CBs is performed (S**206**). The CBs are then multiplexed with control information (S**230**). Meanwhile, the aforementioned steps may be subject to channel coding chain for a data transport block.

Channel coding can be performed for the control information separately from the data information (S**211**). The channel coded control information can later be multiplexed with the data information by a data and control channel rate mapping multiplexer (S**230**).

Channel coding can be performed for the ACK/NACK signals separately from the data and control signals (S**221**). Some of the uplink signals in which the data and control

signals are multiplexed (S230) may be transmitted to the uplink through puncturing (S240).

As described above, the control information that can be transmitted together with the data information is segmented into two types, i.e., uplink (UL) ACK/NACK signals for downlink data and other control information. The uplink ACK/NACK signals for downlink data are transmitted only when downlink data exist. A user equipment may not know whether to receive downlink data even though it should transmit the UL ACK/NACK signals. Accordingly, the user equipment segments the two types of control information from each other and transmits them to the uplink together with the data information. Hereinafter, in order to segment the ACK/NACK signals from the control signals transmitted separately from the ACK/NACK signals, "control signals" will mean those other than the ACK/NACK signals. In more detailed embodiment, the control signals may mean those other than a rank indicator as well as the ACK/NACK signals. In other words, in a specific embodiment, the control signals may include CQI and PMI. However, since the following description relates to efficient arrangement among the control signals, the data signals and the ACK/NACK signals, if the control signals are those other than the ACK/NACK signals, their detailed type will not be suggested.

When the data information is transmitted to the uplink, the data information can be transmitted together with the control information. Also, ACK/NACK information can be transmitted together with the data information and the control information. Moreover, only the data information and the ACK/NACK information can be transmitted to the uplink.

Transmission information sequences obtained to transmit the data information multiplexed with the control information or the ACK/NACK information can be transmitted in accordance with the SC-FDMA scheme. At this time, the transmission information sequences can be mapped in a resource region in accordance with a time-first mapping method.

For example, it is supposed that the information sequences are transmitted using one resource block, i.e., twelve (12) OFDM subcarriers and information is transmitted through one sub-frame. Also, it is supposed that one sub-frame includes fourteen (14) SC-FDMA symbols and two of the fourteen SC-FDMS symbols are used as references signals that are pilot signals. At this time, the number of modulation symbols of the information that can be transmitted to the uplink becomes 12*12=144.

144 information sequence symbols can be transmitted through 12 virtual subcarriers and 12 SC-FDMA symbols. This can be represented by a matrix structure of 12*12 called a time-frequency mapper. The information sequences to be transmitted to the uplink are mapped one by one based on the SC-FDMA symbols. This is called time-first mapping because the SC-FDMA symbols are segmented temporally.

FIG. 3 is a diagram illustrating an example of mapping information sequences according to one embodiment of the present invention in accordance with a time-first mapping method, and FIG. 4 and FIG. 5 are diagrams illustrating a method for transmitting information, which is mapped in accordance with the time-first mapping method as illustrated in FIG. 3, in accordance with the SC-FDMA scheme.

The information sequences to be transmitted to the uplink can be arranged temporally in the time-frequency mapper as illustrated in FIG. 3. In other words, 12 information data are mapped temporally in a first virtual subcarrier region, and then subsequent 12 information data are mapped temporally in a second virtual subcarrier region.

After time-frequency mapping is performed as above, the sequences arranged on a frequency axis as illustrated in FIG. 4 and FIG. 5 undergo DFT and then are inserted to a desired frequency band. Afterwards, IFFT and CP insertion are performed for each frequency region information, which can be transmitted as SC-FDMA symbols. FIG. 4 and FIG. 5 illustrate a procedure of generating and transmitting the SC-FDMA symbols. FIG. 4 illustrates a case where a normal CP is used, and FIG. 5 illustrates a case where an extended CP is used.



When data are transmitted to the uplink, the control information can also be transmitted thereto. At this time, the control information and the data information are multiplexed through rate matching. However, the ACK/NACK information can be transmitted in such a manner that it is overwritten in bit streams of the data information or symbols where data information and control information are multiplexed. In this case, "overwritten" means that specific information mapped in the resource region is skipped and the corresponding region is mapped. Also, "overwritten" means that the length of the entire information is maintained equally even after specific information is inserted. This overwriting procedure may be represented by puncturing.

Generally, the control information requires higher reliability than the data information. To this end, the control information should be multiplexed or inserted near the reference signal. In this case, it is possible to obtain the effect of channel estimation performance, thereby expecting improvement of performance.

However, since the ACK/NACK information also requires high reliability in a receiver, if the general control information is arranged near the reference signal, priority between the control information and the ACK/NACK signals should be considered.

Accordingly, methods for multiplexing data information bit streams, control information bit streams, and ACK/NACK information sequences at different priorities will be described as various embodiments of the present invention.

According to one embodiment of the present invention, the control information is multiplexed serially with the data information, and is mapped with a multiplexing region in accordance with the aforementioned time-first mapping method. In this case, "multiplexed serially" means that the data information is mapped with a sequence corresponding to the multiplexed result directly after the control information is mapped with the sequence, or vice versa. Also, according to one embodiment of the present invention, the ACK/NACK signals are arranged to be transmitted through both symbols near a symbol through which the reference signal is transmitted.

FIG. 6 is a diagram illustrating a method for transmitting uplink signals in accordance with one embodiment of the present invention.

According to this embodiment, when the control information and the data information are multiplexed, they are serially connected with each other so that they are mapped with SC-FDMS symbols in accordance with the time-first mapping method and then are transmitted to the uplink. If the ACK/NACK information should also be transmitted, among the serially multiplexed data, modulation symbols located near the reference signal are punctured so that the ACK/NACK signals are inserted thereto. In FIG. 6, a reference numeral 601 illustrates that the data and control signals are multiplexed serially if the ACK/NACK signals are not transmitted. A reference numeral 602 illustrates that the ACK/NACK signals are arranged by puncturing the multiplexed data if the ACK/NACK signals should be transmitted to the uplink. Also, a reference numeral 603 illustrates that information sequences such as the reference numeral 602 are

mapped in the time-frequency region in accordance with the time-first mapping method. In the reference numeral **603** of FIG. **6**, it is supposed that the reference signal is transmitted through a part between symbol indexes #**3** and #**4** and a part between symbol indexes #**9** and #**10**.

As can be aware of it from the mapping type illustrated in the reference numeral **603** of FIG. **6**, after the control signals are serially connected with data and then multiplexed, they are mapped in the time-frequency region in accordance with the time-first mapping method. Also, the ACK/NACK signals can be set in such a manner that they are overwritten in the data signals multiplexed with two symbols (symbols #**3**, **4**, **9** and **10** in FIG. **6**) at both sides of the SC-FDMA symbols to which the reference signal is transmitted;

FIG. **7** and FIG. **8** are diagrams illustrating a method for processing a number of ACK/NACK information data to be transmitted in accordance with one embodiment of the present invention.

In detail, when the number of ACK/NACK information data to be transmitted is more than the number of subcarriers (of a virtual frequency region) to which data are transmitted before and after the reference signal, the ACK/NACK information can be transmitted through additional SC-FDMA symbols in addition to both symbols nearest to the reference signal. In FIG. **7** and FIG. **8**, the ACK/NACK information is transmitted through additional symbols in the order of the symbols near reference symbols in addition to both symbols near the reference symbols.

At this time, the SC-FDMA symbols existing based on the reference signal may not be arranged symmetrically depending on a structure of the SC-FDMA sub-frame of the uplink as illustrated in FIG. **8**. Accordingly, considering this, the ACK/NACK information should be inserted by puncturing.

When the control information is arranged on the time-axis in accordance with the aforementioned embodiment of the present invention, the control information and the data information are arranged in due order so that they are mapped in the resource region. Also, if the ACK/NACK information is arranged near the reference signal, the ACK/NACK information can be overwritten in the control information as well as the data information.

FIG. **9** is a diagram illustrating that the ACK/NACK signals are inserted by puncturing the control signals as well as the data signals in accordance with another embodiment of the present invention.

According to this embodiment, since the ACK/NACK information is substantially control information, priority is given to control information channels, so that the control information channel having the highest priority is arranged near the reference signal for protection of channel estimation while the control information channels having relatively low priority are sequentially mapped on the time axis and then transmitted. Particularly, in this embodiment, it is supposed that the ACK/NACK information has higher priority than the control information. At this time, the control information and the data information are sequentially arranged on the time axis in accordance with the time-first mapping method and then multiplexed. The ACK/NACK information punctures the data/control information located near the reference signal.

In detail, a reference numeral **901** of FIG. **9** illustrates that the data and control signals are multiplexed if the ACK/NACK signals need not to be transmitted. A reference numeral **902** of FIG. **9** illustrates that data, control signals and ACK/NACK signals are multiplexed if the ACK/NACK signals should be transmitted. Also, a reference numeral **903** of FIG. **9** illustrates that the multiplexed uplink signals are mapped in the time-frequency region as illustrated in the reference numeral **902**.

As illustrated in the reference numeral **903** of FIG. **9**, it is noted from this embodiment that the ACK/NACK signals can puncture the control signals as well as the data matched near the reference signal. In this way, if resource mapping is performed by giving priority to the control signals, good channel estimation effect can be obtained as the ACK/NACK information is located near the reference signal. On the other hand, since a small number of control signals are punctured by the ACK/NACK signals, it may not affect performance. In one embodiment shown in FIG. **9**, the ACK/NACK signals may puncture the control signals/data equally distributed in the virtual frequency axis. That is, if the number of virtual subcarriers available for the above puncturing by the ACK/NACK signals is "N" and the number of ACK/NACK to be transmitted per SC-FDMA symbol is "m", the ACK/NACK signals may puncture the control signals/data equally distributed having the interval of "N/m" or equivalent.

Also, since the control information and the data information are multiplexed simply, a multiplexing block can be formed simply.

Hereinafter, a whole procedure of transmitting uplink signals in accordance with the aforementioned embodiments of the present invention will be described. For convenience of description, this procedure will be described with reference to FIG. **2**.

In order to transmit the uplink signals in accordance with each of the embodiments of the present invention, the transmitter performs channel coding for each of data signals, control signals, and ACK/NACK signals. Channel coding for each of the uplink signals can be performed independently as illustrated in FIG. **2**.

At this time, as illustrated in FIG. **2**, the procedure of performing channel coding for the data signals can include steps of segmenting a TB attached with CRC for TB in a unit of CB (S**202**), attaching a CRC for CB to the segmented CBs (S**203**), performing channel coding for the data attached with the CRC for CB (S**204**), performing rate matching for the channel coded data (S**206**), and performing CB concatenation (S**207**).

The one embodiment of the present invention suggests that the channel coded data and control signals are multiplexed serially. Serial multiplexing means that the control signals are mapped with sequential indexes directly after the data signals are mapped with them, or vice versa. Meanwhile, the multiplexed signals can sequentially be mapped within a specific resource region in accordance with the time-first mapping method, wherein the specific resource region includes a plurality of symbols (for example, 12 SC-FDMA symbols) and a plurality of virtual subcarriers.

In addition, in this embodiment of the present invention, the ACK/NACK signals are preferably arranged near the symbols to which the reference signal is transmitted, among the plurality of symbols.

It will be apparent to those skilled in the art that the present invention can be embodied in other specific forms without departing from the spirit and essential characteristics of the invention. Thus, the above embodiments are to be considered in all respects as illustrative and not restrictive. The scope of the invention should be determined by reasonable interpretation of the appended claims and all change which comes within the equivalent scope of the invention are included in the scope of the invention.

The embodiments of the present invention can be applied to various systems, which require data signal transmission, control signal transmission, and ACK/NACK signal transmission through the uplink, in addition to the 3GPP LTE system.

What is claimed is:

**1**. A method for transmitting uplink signals comprising control signals and data signals in a wireless communication system, the method comprising:

(a) serially multiplexing first control signals and data signals in a mobile station, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals;

(b) mapping the multiplexed signals to a 2-dimensional resource matrix comprising a plurality of columns and a plurality of rows, wherein the columns and the rows of the 2-dimensional resource matrix correspond to single carrier frequency divisional multiple access (SC-FDMA) symbols and subcarriers for each SC-FDMA symbol, respectively, wherein a number of columns of the 2-dimensional resource matrix corresponds to a number of SC-FDMA symbols within one subframe except specific SC-FDMA symbols used for a reference signal, and wherein the multiplexed signals are mapped from the first column of the first row to the last column of the first row, the first column of the second row to the last column of the second row, and so on, until all the multiplexed signals are mapped to the 2-dimensional resource matrix

(c) mapping ACK/NACK control signals to specific columns of the 2-dimensional resource matrix, wherein the specific columns correspond to SC-FDMA symbols right adjacent to the specific SC-FDMA symbols, wherein the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix at step (b) from the last row of the specific columns; and

(d) transmitting the signals mapped to the 2-dimensional resource matrix at steps (b) and (c) by column by column to a base station.

2. The method of claim 1, wherein the first control signals comprise at least one of:

precoding matrix index (PMI) signals; or

channel quality indicator (CQI) signals.

3. The method of claim 1, wherein one subframe comprises two slots, wherein the specific SC-FDMA symbols correspond to fourth SC-FDMA symbols out of seven SC-FDMA symbols in each slot.

4. The method of claim 1, wherein the ACK/NACK control signals are transmitted via subcarriers corresponding to third SC-FDMA symbols and fifth SC-FDMA symbols out of seven SC-FDMA symbols in each slot.

5. The method of claim 1, wherein the ACK/NACK control signals are channel coded independently of the data signals or first control signals.

6. The method of claim 1, wherein the step (d) comprises:

respectively performing a discrete Fourier transform (DFT) for the signals mapped to each column of the 2-dimensional resource matrix signals;

respectively performing an inverse fast Fourier transform (IFFT) on the DFT-transformed signals corresponding to the signals mapped to each column of the 2-dimensional resource matrix signals;

respectively attaching a cyclic prefix to the IFFT-transformed signals corresponding to the signals mapped to each column of the 2-dimensional resource matrix signals; and

transmitting the cyclic prefix attached signals to the base station.

7. The method of claim 1, wherein the signals mapped to the 2-dimensional resource matrix are transmitted through a physical uplink shared channel (PUSCH).

8. A mobile station for transmitting uplink signals comprising control signals and data signals in a wireless communication system, the mobile station comprising:

a processor serially multiplexing first control signals and data signals, wherein the first control signals are placed at a front part of the multiplexed signals and the data signals are placed at a rear part of the multiplexed signals;

the processor mapping the multiplexed signals to a 2-dimensional resource matrix comprising a plurality of columns and a plurality of rows, wherein the columns and the rows of the 2-dimensional resource matrix correspond to single carrier frequency divisional multiple access (SC-FDMA) and subcarriers for each SC-FDMA symbol, respectively, wherein a number of columns of the 2-dimensional resource matrix corresponds to a number of SC-FDMA symbols within one subframe except specific SC_FDMA symbols used for a reference signal, and wherein the multiplexed signals are mapped from the first column of the first row to the last column of the first row, the first column of the second row to the last column of the second row, and so on, until all the multiplexed signals are mapped to the 2-dimensional resource matrix; and

the processor mapping ACK/NACK control signals to specific columns of the 2-dimensional resource matrix, wherein the specific columns correspond to SC-FDMA symbols right adjacent to the specific SC-FDMA symbols, wherein the ACK/NACK control signals overwrite some of the multiplexed signals mapped to the 2-dimensional resource matrix from the last row of the specific columns.

9. The mobile station of claim 8, wherein the first control signals comprise at least one of:

precoding matrix index (PMI) signals; or

channel quality indicator (CQI) signals.

10. The mobile station of claim 8, wherein one subframe comprises two slots, wherein the specific SC-FDMA symbols correspond to fourth SC-FDMA symbols out of seven SC-FDMA symbols in each slot.

11. The mobile station of claim 8, wherein the ACK/NACK control signals are transmitted via subcarriers corresponding to third SC-FDMA symbols and fifth SC-FDMA symbols out of seven SC-FDMA symbols in each slot.

12. The mobile station of claim 8, wherein the ACK/NACK control signals are channel coded independently of the data signals or first control signals.

13. The mobile station of claim 8, wherein the processor further adapted for:

respectively performing, a discrete Fourier transform (DFT) the signals mapped to each column of the 2-dimensional resource matrix signals;

respectively performing an inverse fast Fourier transform (IFFT) on the DFT-transformed signals corresponding to the signals mapped to each column of the 2-dimensional resource matrix signals;

respectively attaching a cyclic prefix to the IFFT-transformed signals corresponding to the signals mapped to each column of the 2-dimensional resource matrix signals; and

transmitting the cyclic prefix attached signals to a base station.

14. The mobile station of claim 8, wherein the signals mapped to the 2-dimensional resource matrix are transmitted through a physical uplink shared channel (PUSCH).

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION



PATENT NO. : 8,102,833 B2
APPLICATION NO. : 12/209136
DATED : January 24, 2012
INVENTOR(S) : Lee et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

Column 10, Line 8-12, delete "wherein the columns and the rows of the 2-dimensional resource matrix correspond to single carrier frequency divisional multiple access (SC-FDMA) and subcarriers for each SC-FDMA symbol," and insert -- wherein the columns and the rows of the 2-dimensional resource matrix correspond to single carrier frequency divisional multiple access (SC-FDMA) symbols and subcarriers for each SC-FDMA symbol, --, therefor.

Signed and Sealed this
Seventh Day of November, 2017

Joseph Matal

Joseph Matal
*Performing the Functions and Duties of the*
*Under Secretary of Commerce for Intellectual Property and*
*Director of the United States Patent and Trademark Office*

**CERTIFICATE OF SERVICE**

I hereby certify that, on this 28th day of April, 2025, I filed the foregoing Corrected Non-Confidential Brief for Appellant Apple Inc. with the Clerk of the United States Court of Appeals for the Federal Circuit via the CM/ECF system, which will send notice of such filing to all registered CM/ECF users.

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## CERTIFICATE OF CONFIDENTIAL MATERIAL

The foregoing document contains 14 number of unique words (including numbers) marked confidential.

- [X] This number does not exceed the maximum of 15 words permitted by Fed. Cir. R. 25.1(d)(1)(A).

- [ ] This number does not exceed the maximum of 50 words permitted by Fed. Cir. R. 25.1(d)(1)(B) for cases under 19 U.S.C. § 1516a or 28 U.S.C. § 1491(b).

- [ ] This number exceeds the maximum permitted by Federal Circuit Rule 25.1(d)(1), and the filing is accompanied by a motion to waive the confidentiality requirements.

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April 28, 2025

## CERTIFICATE OF COMPLIANCE WITH TYPE-VOLUME LIMITATIONS

The foregoing filing complies with the relevant type-volume limitation of the Federal Rules of Appellate Procedure and Federal Circuit Rules because:

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